DOCUMENT RESUME

ED 469 870 CE 084 027

AUTHOR	Kaltwasser, Stan; Flowers, Gary; Blasingame, Don
TITLE	Basic Wiring. Fourth Edition. Teacher Edition [and] Student Guide [and] Student Workbook 1 [and] Student Workbook 2.
INSTITUTION	Multistate Academic and Vocational Curriculum Consortium, Stillwater, OK.
PUB DATE	2002-00-00
NOTE	1234p.; Revised by Dan Ipock and Glenn Fleming. Project coordinated by Glenn Fleming. For related modules, see CE 084 028-029. For the 3rd edition (1999), see ED 432 678. For related publications, see CE 084 028-029.
AVAILABLE FROM	Multistate Academic and Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, OK 74074 (order no. 801301 (Teacher ed.) $165; order no. 801302 (Student ed.) $42.50; order no. 081342 (Student Workbook) $48.50). Tel: 800-654-3988 (Toll Free); e-mail: mavccweb@okcareertech.org; Web site: http://www.mavcc.org.
PUB TYPE	Guides - Classroom - Learner (051) -- Guides - Classroom - Teacher (052)
EDRS PRICE	EDRS Price MF09 Plus Postage. PC Not Available from EDRS
DESCRIPTORS	Basic Skills; *Electric Circuits; Electrical Occupations; *Electrical Systems; *Electricians; *Electricity; First Aid; Hand Tools; *Instructional Materials; Learning Activities; Mathematics; Measurement; Mechanical Equipment; Occupational Information; Postsecondary Education; Safety; *Safety Education; Secondary Education; Student Evaluation; Teaching Guides; Technical Education; Tests; Trade and Industrial Education; Workbooks
IDENTIFIERS	Crosswalks (Linking); *Electrical Wiring

ABSTRACT

Basic Wiring, first in a series of three wiring publications, serves as the foundation for students enrolled in a wiring program. It is a prerequisite to Commercial and Industrial Wiring or Residential Wiring. Instructional materials include a teacher edition, student guide, and two student workbooks. The teacher edition begins with introductory pages, including a training and competency profile, duty-task crosswalk, instructional/task analysis, basic skills icons and classifications, basic skills matrix, and a tools, equipment, and materials list. Each of 17 units consists of some or all of these components: suggested activities (instructional plan, teaching suggestions, references used in unit development, suggested supplemental resources); assignment sheet answer keys; written test; test key; teacher supplements; and transparency masters. The student guide provides some or all of these for each unit: learning activities sheet; objective sheet; information sheet; and student supplements. The student workbook contains these pen-and-paper exercises and skill tests necessary for student mastery of the course: focus assignment (provides students with an opportunity to explore topics presented in a unit and practice their reading, language skills, and critical thinking skills); assignment sheets; and job sheets. The 17 units are occupational information; general safety and first aid; electrical safety; related math and measuring; hand tools; powered/specialty tools and equipment; using trade information; basic equipment; basic theory; DC circuits; AC circuits; wiring methods; conductors; low voltage wiring; overcurrent protection; load centers and

Reproductions supplied by EDRS are the best that can be made
from the original document.

safety switches; and existing structures. (YLB)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 469 870

Basic Wiring, Fourth Edition

Teacher Edition

[and]

Student Guide

[and]

Student Workbook 1

[and]

Student Workbook 2

MAVCC

References 2002
National Electrical Code

02-015641	CN801301
02-015641	CN801302
02-015641	CN801342
02-015641	CN801342

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

■ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality

Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

A. Pratt

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

2B

CE 084 027

BEST COPY AVAILABLE

BASIC WIRING

Fourth Edition

Teacher Edition

4
5
6
MADE IN U.S.A.
WEAR SAFETY GOGGLES

References 2002 *National Electrical Code*

02-015641

CN801301

3

Basic Wiring

Fourth Edition

Teacher Edition

Written by

Stan Kaltwasser
Gary Flowers
Don Blasingame

Revised by

Dan Ipock
Glenn Fleming

Project coordinated by

Glenn Fleming

Developed by

The Multistate Academic and Vocational Curriculum Consortium, Inc.

Board of Directors

Kimberly Sadler, Oklahoma, Chair
John Davidson, Arkansas
Jimmy Hogg, Georgia
Jim Fleihler, Iowa
Ben Clay, Kansas
Connie Buck, Louisiana
Roberta Brown, Pennsylvania
Larry Nelson, South Dakota
Lynne Cohen, Tennessee
Esther Camacho, Texas

Jane Huston, Executive Director

02-015641

801301

©2002 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Printed in the United States of America by the
Oklahoma Department of Career and Technology Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

5

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Table of Contents

Introductory Pages

Foreword ix
Acknowledgments xi
Use of this publication xiii
Training and competency profile xxi
Duty-task crosswalk xxv
Instructional/task analysis xxix
Basic skills icons and classifications xli
Basic skills matrix xlv
Tools, equipment, and materials list lix

Units of Instruction

Unit 1: Occupational Introduction

Unit 2: General Safety and First Aid

Unit 3: Electrical Safety

Unit 4: Related Math and Measuring

Unit 5: Hand Tools

Unit 6: Powered/Specialty Tools and Equipment

Unit 7: Using Trade Information

Unit 8: Basic Equipment

Unit 9: Basic Theory

Unit 10: DC Circuits

Unit 11: AC Circuits

Unit 12: Wiring Methods

Unit 13: Conductors

Unit 14: Low Voltage Wiring

Unit 15: Overcurrent Protection

Unit 16: Load Centers and Safety Switches

Unit 17: Existing Structures

MAVCC Customer Feedback Form

MAVCC is committed to providing instructors and students with current, accurate, and effective instructional materials. As you use our products, we hope you will find that they contribute to the quality of your program. However, if you find any errors, have any suggestions for improvement of the materials, or have ideas for additional products, please use the form below. After completing the form, simply fold, secure and mail. Or, simply e-mail your corrections and/or suggestions to feedback@mavcc.com.

Corrections

Publication Title ______________________________

Page Number	Correction

Suggestions

- Product Needs (supplemental resources, additional publications, etc.)

____
____
____
____
____
____

- Other Ideas

____
____
____
____
____
____

Optional Information

Name ______________________________

Address ______________ City ______________ State ________ Zip ________

E-mail address ______________________________

MAVCC **Great Products...Great Prices...Great Results**

1-800-654-3988 www.mavcc.com feedback@mavcc.com

Fold here

Place
Stamp
Here

MAVCC
1500 W. Seventh Ave.
Stillwater, OK 74074-4364

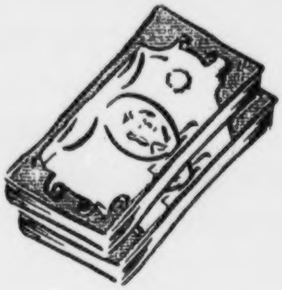
Fold here

Instructors:

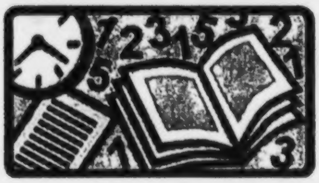
Have you ordered your student materials?

If not, you are missing an important resource that will help you increase your students' classroom performance and help them succeed in the workplace.

Benefits of Student Editions



- **Save money** by purchasing 6 or more copies (up to 42% off of the single copy price).
- **Save additional money** by only needing to purchase student workbooks each year



- **Ensure sequential learning** by using MAVCC's unique format that moves the student from simple to complex objectives.
- **Save time** by using this complete, ready-to-teach instructional resource.

Key Components of Student Editions

Student Guides	Student Workbooks
◊ Learning Activities Sheet	◊ Focus Assignments
◊ Objective Sheet	◊ Assignment Sheets
◊ Information Sheet	◊ Job Sheets
◊ Student Supplements	

For more information about these components, please refer to the "Use of This Publication" section found in the front of your teacher edition

Contact MAVCC now to purchase your student editions:

• Phone	1-800-654-3988
• E-mail	mavcc@mavcc.com
• Online catalog	www.mavcc.com

Remember, MAVCC publications are **copyrighted**, and it is against the law to photocopy and distribute any part of this material unless otherwise noted on the page. Examples of components teachers are allowed to photocopy include the written test, competency profile, and learning activities sheet.

Foreword

Basic Wiring is the first in a series of three wiring publications and serves as the foundation for students enrolled in a wiring program. It is a prerequisite to either *Commercial and Industrial Wiring* or *Residential Wiring*. An applied math unit is included in this edition to reinforce computational skills needed in the wiring industry. This series should provide the flexibility that instructors need to meet the individual needs of their students and the community.

Residential Wiring, is the second publication in the series and prepares students for entry-level employment in the residential wiring trade.

Commercial and Industrial Wiring, is the third in a series of three wiring publications and includes the additional technical knowledge and applications required for job entry in the commercial and industrial wiring trade.

This edition of *Basic Wiring* includes a student workbook that contains focus assignments, assignment sheets, and job sheets. Student workbooks can be purchased individually each year to provide new students with the focus, assignment, and job sheets needed to master the course.

MAVCC's wiring series was developed with the assistance of many individuals who have expertise in various areas of the wiring trade. Some of these individuals represent professional associations and industry. Their assistance and support is greatly appreciated. It should be emphasized that the student needs to be aware of professional trade associations and take an active part in them as much as possible. The professional trade association, as well as vocational education, are an excellent avenue for continuing education within the electrical trade.

These instructional materials are designed not only for student use but also to assist the teacher in improving instruction. Every effort has been made to make these materials basic, readable, and usable. Teachers will need to develop instructional strategies for localizing, individualizing, and supplementing these materials.

As you use these instructional materials, we hope you will find they contribute to the quality of your program. If any problems occur or if you have suggestions for improvement, please call or write us.

Kimberly Sadler, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum
Consortium

Jane Huston
Executive Director
Multistate Academic and
Vocational Curriculum
Consortium

Acknowledgments

Appreciation is extended to those individuals who contributed their time and talent to the development of *Basic Wiring*.

The contents of this publication were initially planned and reviewed by the following committee members:

Loren Amerine	Hoisington, Kansas
Bill Barnes	Littleton, Colorado
Harold Brown	Hope, Arkansas
Daniel Frohberg	Norfolk, Nebraska
Tracy Naas	Kloten, North Dakota
Mike Pedersen	Sheldon, Iowa
Clifford Schaefer	Ft. Worth, Texas
Randy Wilson	Stillwater, Oklahoma

Review and revision of this publication was completed by selected instructors in the Oklahoma Career and Technology Education system.

A special thank you goes to the following for granting MAVCC permission to reprint certain graphic materials that enhance this text: Jim Johnson, Telemecanique, Inc.; Marc McCord, Advance Transformer Company; John Henry, Challenger Electrical Equipment Corporation; ERICO Products, Inc.; American Technical Publishers; Bennett Publishing Company; NUS Training Corporation; General Electric Company, and the American Association of Vocational Instructional Materials.

Special thanks are also extended to Rick Lomenick, electronic publishing technician, for his hard work, accuracy, and determination in completing revisions and re-formatting this edition.

Appreciation is extended to employees of the Graphics Division of the Oklahoma Department of Career and Technology Education for artwork and printing of this text.

Use of This Publication

Basic Wiring is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the Electrical Wiring advisory committee, comprised of business/industry representatives and teachers. Competencies align with the Oklahoma Duty/Task List developed by the Oklahoma Department of Vocational and Technical Education.

Teacher Edition

The complete teacher edition consists of introductory pages, teacher pages, the student guide, and the student workbook. The introductory and teacher pages are loose-leaf and three-hole punched. The student guide is spiral bound, and the student workbook is perfect bound with the pages perforated for easy removal. Each are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit in the teacher pages is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Example:

Page 17 of Unit 3 in the teacher pages is represented as T 3–17.

MAVCC—*Basic Wiring* T 3-17

Pages in the student workbook are sequentially numbered beginning with page 1.

MAVCC *Basic Wiring* Page 1

Page 7 of Unit 5 in the student guide is represented as Page 5–7.

MAVCC—*Basic Wiring* Page 5-7

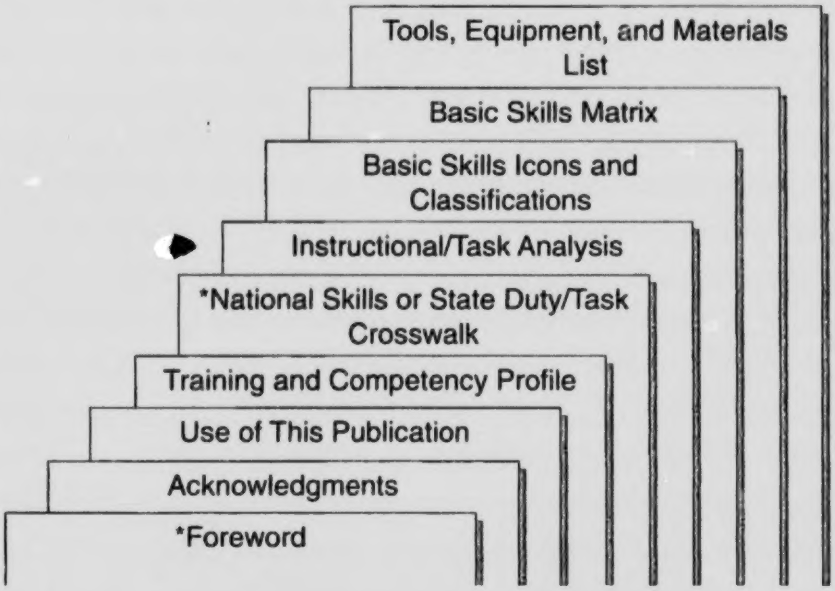
Use of This Publication

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages


Tools, Equipment, and Materials List
Basic Skills Matrix
Basic Skills Icons and Classifications
Instructional/Task Analysis
*National Skills or State Duty/Task Crosswalk
Training and Competency Profile
Use of This Publication
Acknowledgments
*Foreword

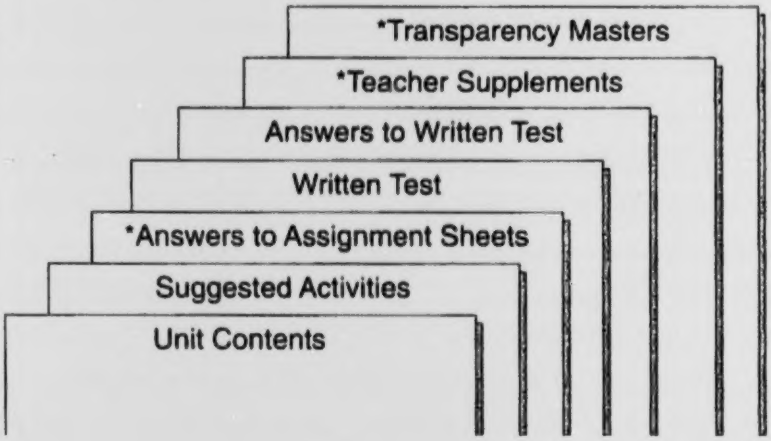
*Designates items that may not appear in every publication

Use of This Publication

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

- ☐ **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.
- ☐ **National Skills and/or State Duty/Task Crosswalk.** This document identifies the national and/or state skill standards covered in this publication and lists specifically where these skills are located by unit number and objective.
- ☐ **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.
- ☐ **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each focus assignment, assignment sheet, and job sheet.
- ☐ **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.
- ☐ **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Teacher Pages



*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

- ☐ **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

  Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

- ☐ **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

- ☐ **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

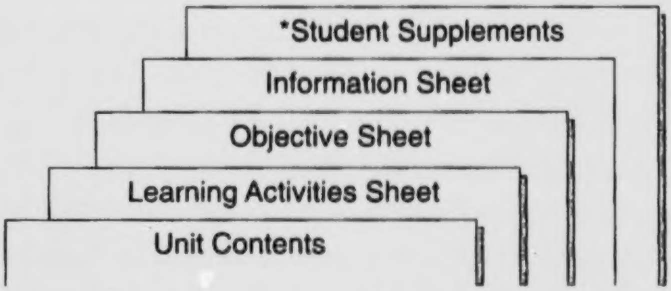
Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

☐ **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

☐ **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

☐ **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Guide



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

☐ **Learning Activities Sheet.** This component can be used to guide the student in self-paced or individualized programs, and in other programs provides the student with an overview of how components interface within the unit. It's designed to guide the student through the required and optional components in the student edition (objective sheet, information sheet, and student supplements). The teacher is encouraged to use this component as a model and modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student.

The following icons will be used on the learning activities sheet to denote steps that require additional resources:

📖 Read a book, magazine, or journal article

💻 Use a CBT program or other software application

WWW Access a site on the World Wide Web

🖥 Look at PowerPoint® or other computer presentation

📼 Watch a videotape

☐ **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

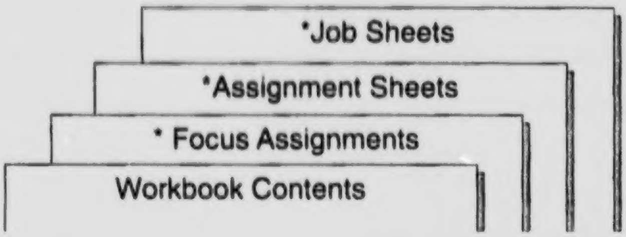
The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

☐ **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

☐ **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

Student Workbook



*Designates components that may not appear in every unit of instruction.

The student workbook is an integral part of the student materials and should be provided to each student. It contains the pen-and-paper exercises and skill tests necessary for student mastery of the course.

☐ **Focus Assignment.** This activity provides students with an opportunity to explore topics presented in a specific unit of instruction, and gives them an opportunity to practice their reading, language skills including writing and speaking, and critical-thinking skills.

☐ **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

☐ **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or E-mail us at mavcc@mavcc.com.

Training and Competency Profile

Student Information

Program ______________________ Instructor ______________________

Name ______________________ Soc. Sec. No. ______________________

Address ______________________ Phone ______________________

Grade ______________ School ______________________

Allergies/Disabilities that might require special accommodation for training (please specify)

____

In case of emergency, contact ______________________ Phone ______________

Record of Enrollment

Date of Enrollment ____- ____- ____ Total Class Hours________ Total Hours Absent________

Date of Withdrawal ____- ____- ____ Total On-the-Job Training Hours________ Total Hours Tardy________

Date of Completion ____- ____- ____ Total Lab Hours__________

On-the-Job Training/Work Experience

______________________ ______________________

Place of Employment Address

______________________ ______________________

Supervisor's Name Phone

______________________ ______________________

Duration of Employment Job Title

____

Job Responsibilities

______________________ ______________________

Place of Employment Address

______________________ ______________________

Supervisor's Name Phone

______________________ ______________________

Duration of Employment Job Title

____

Job Responsibilities

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using one of the rating scales below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scorelines are provided for optional teacher use. They may not be applicable in all cases.

Sample A

4 **Skilled**—Can perform job with no additional training.
3 **Moderately Skilled**—Has performed job during training program; limited additional training may be required.
2 **Limited Skill**—Has performed job during training program; additional training is required to develop skill.
1 **Unskilled**—Is familiar with process, but is unable to perform job.
0 **No Exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

Unit 1: Occupational Introduction

_______ 1. List careers associated with the electrical trade.
_______ 2. Interview an electrical worker.
_______ 3. Compare employment opportunities in the electrical field.
_______ 4. ______________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 2: General Safety and First Aid

_______ 1. Locate material safety data sheets.
_______ 2. Interpret a material safety data sheet.
_______ 3. Draw a layout of your school shop and apply the safety color code.
_______ 4. State portable fire extinguisher types, symbols, and operating instructions.
_______ 5. Identify and correct safety violations.
_______ 6. Operate a fire extinguisher.
_______ 7. Lift a heavy object properly.
_______ 8. Place and climb a ladder safely.
_______ 9. ______________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 3: Electrical Safety

_______ 1. Read about controlling electrical hazards.
_______ 2. Identify and describe safety violations.
_______ 3. Solve problems concerning electrical safety practices.
_______ 4. ______________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 4: Related Math Measuring

_______ 1. Add whole numbers.
_______ 2. Subtract whole numbers.
_______ 3. Multiply whole numbers.
_______ 4. Divide whole numbers.
_______ 5. Reduce fractions to lowest terms.
_______ 6. Convert fractions and mixed numbers.
_______ 7. Add fractions.
_______ 8. Subtract fractions.
_______ 9. Multiply fractions.
_______ 10. Add decimal numbers.
_______ 11. Subtract decimal numbers.
_______ 12. Multiply decimal numbers.
_______ 13. Divide decimal numbers.
_______ 14. Convert fractions and percentages.
_______ 15. Solve percentage problems.
_______ 16. Calculate area of geometric figures.
_______ 17. ______________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 5: Hand Tools

_______ 1. List and price electrician's tools.
_______ 2. Measure objects using a tape measure.
_______ 3. Clean and lubricate an adjustable hand tool.
_______ 4. Use a cutting/crimping tool.
_______ 5. Adjust wire strippers.
_______ 6. Set up and use a hacksaw to cut conduit.
_______ 7. Ream and thread rigid conduit.
_______ 8. Bend EMT conduit.
_______ 9. Use a knockout punch.
_______ 10. Use a hole saw.
_______ 11. ______________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Training and Competency Profile

Unit 6: Powered/Specialty Tools and Equipment

______ 1. Determine dimensions on a drawing using an architects scale.
______ 2. Use hydraulic knockout punch.
______ 3. Bend a 90-degree stub using a hydraulic pipe bender.
______ 4. Make offset and 90-degree bend using an electric PVC heater.
______ 5. Cut, ream, and thread rigid conduit with a power threader.
______ 6. Measure resistance using a VOM.
______ 7. Measure DC voltages using a VOM.
______ 8. Measure AC voltages using a VOM.
______ 9. Measure amperages using a clam-on ammeter.
______ 10. Determine the current of a multiple loop using a clam-on ammeter.
______ 11. Check conductor insulation with a megger.
______ 12. ______________________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 7: Using Trade Information

______ 1. Using the *National Electrical Code*.
______ 2. Use the *National Electrical Code* index to answer questions about *Code* sections.
______ 3. Using the *National Electrical Code* title page, table of contents, and introduction to answer questions.
______ 4. Use the *National Electrical Code* first chapter to define terms.
______ 5. Use the *National Electrical Code* to answer general questions related to residential wiring.
______ 6. Use the *National Electrical Code* to locate allowable ampacities for various conductors.
______ 7. Use the *National Electrical Code* to interpret conduit fill tables.
______ 8. Find information in the *National Electrical Code*.
______ 9. ______________________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 8: Basic Equipment

______ 1. Determine the correct number of conductors for boxfill.
______ 2. Install outlet boxes on wood studs on a framed wall.
______ 3. Install outlet boxes on steel structures and rods using caddy clips.
______ 4. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes.
______ 5. Install masonry boxes in a block wall.
______ 6. ______________________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 9: Basic Theory

______ 1. Draw a diagram of the power distribution supplying your school or shop or home.
______ 2. Solve problems for unknown voltage.
______ 3. Solve problems for unknown amperage.
______ 4. Solve problems for unknown resistances and wattages.
______ 5. Solve problems for an unknown quantity.
______ 6. ______________________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 10: DC Circuits

______ 1. Solve problems for unknown current.
______ 2. Solve problems for unknown resistance.
______ 3. Solve problems for unknown voltage.
______ 4. Determine total resistance in series circuits.
______ 5. Determine unknown resistance values in series circuits.
______ 6. Solve problems for unknown current in series circuits.
______ 7. Solve problems for unknown resistance in series circuits.
______ 8. Solve problems for unknown voltage in series circuits.
______ 9. Apply Kirchoff's voltage law to series circuits.
______ 10. Solve problems for unknown resistance in parallel circuits.
______ 11. Solve problems for unknown current in parallel circuits.
______ 12. Apply Kirchoff's current law to parallel circuits.
______ 13. Solve problems for unknown resistance in series-parallel circuits.
______ 14. Solve problems for unknown voltage in series-parallel circuits.
______ 15. Solve problems for unknown current in series-parallel circuits.
______ 16. Compute power using Ohm's law.
______ 17. ______________________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 11: AC Circuits

______ 1. List facts about producing AC electricity.
______ 2. Solve RC and RL circuit problems.
______ 3. Solve power factor problems.
______ 4. Draw a diagram of a single-pole switch on a light.
______ 5. Draw a diagram of two three-way switches on a light.
______ 6. Draw a diagram of two three-way switches and a four-way switch on a light.
______ 7. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the switch box.
______ 8. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box.
______ 9. Wire a three-way switching situation with the supply line entering a single lighting outlet.

Training and Competency Profile

_______ 10. Wire a four-way switching situation with the supply line entering the lighting outlet box.
_______ 11. ____________________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit12: Wiring Methods

_______ 1. Identify environments and structures requiring electrical wiring installations.
_______ 2. Reference the *National Electrical Code* to identify uses of wiring methods.
_______ 3. Install a set-screw conduit fitting.
_______ 4. Install a compression-type conduit fitting.
_______ 5. Prepare MC cable for termination.
_______ 6. Install a connector onto liquidtight flexible metallic conduit.
_______ 7. Install a connector onto rigid nonmetallic conduit.
_______ 8. ____________________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 13: Conductors

_______ 1. Report on an electrical fire.
_______ 2. List conductors in order, by size.
_______ 3. Calculate ampacity of conductors, given insulation and conductor type.
_______ 4. Calculate corrected ampacity of conductors.
_______ 5. Select conductors for various ampacities and temperatures.
_______ 6. Calculate ampacity of conductors, given number of conductors in raceway.
_______ 7. Calculate ampacity and conductor sizes for specific types of loads.
_______ 8. Select cords for various applications.
_______ 9. Select proper types of insulation.
_______ 10. Install cord on utilization equipment.
_______ 11. Use a fish tape to install wire in conduit.
_______ 12. Prepare an aluminum conductor for termination.
_______ 13. Splice solid conductors using a wire nut.
_______ 14. ____________________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 14: Low Voltage Wiring

_______ 1. List licensing requirements for low voltage wiring systems.
_______ 2. Draw a wiring diagram indicating the proper connection for bell circuit equipment.
_______ 3. Draw a wiring diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors.
_______ 4. Wire a two-button chime circuit.
_______ 5. Wire two interconnecting smoke detectors.
_______ 6. ____________________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 15: Overcurrent Protection

_______ 1. Identify overcurrent protective devices
_______ 2. Calculate conductor and fuse sizes.
_______ 3. Test cartridge fuses.
_______ 4. ____________________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 16: Load Centers and Safety Switches

_______ 1. Determine cost of load center construction.
_______ 2. Using the *NEC*, answer questions related to load centers.
_______ 3. Install a safety switch.
_______ 4. Wire a load center or breaker panel.
_______ 5. Wire a receptacle circuit to a load center.
_______ 6. ____________________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Unit 17: Existing Structures

_______ 1. Determine the number of conductors allowed to be added to an existing conduit.
_______ 2. Install a metallic box with dry-wall grips in a plasterboard wall.
_______ 3. Secure a box with dry-wall supports (box tins).
_______ 4. Install a plastic box with dry wall grips in a plasterboard wall.
_______ 5. Install a box in a paneled wall.
_______ 6. Install a box in a concrete block wall.
_______ 7. Install a box in a brick wall
_______ 8. Install a box in a ceiling with an accessible attic.
_______ 9. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind base board.
_______ 10. Install cable between an existing box and a newly installed box, using an underfloor crawl space.
_______ 11. Install cable between an existing box and a newly installed box, using attic space.
_______ 12. ____________________________________

Written Test Scores
Pretest Score _________%
Posttest Score _________%

Duty/Task Crosswalk

This duty/task crosswalk is based on the Oklahoma Duty/Task List for the Electrical Trades, Residential Electrical Assistant, and can be used as a cross-reference in other states.

Abbreviations:

FA—Focus Assignment
AS—Assignment Sheet
JS—Job Sheet

Skill Code	Skill Description	Unit #	Specific Reference
E.02	Inventory equipment and supplies	2, 5, 6 8-17	
F.01	Construct/analyze/install series circuits	10	Objectives 4-6
F.03	Draw series circuit and calculate circuit values	10	AS 1-9
F.04	Construct/analyze/install parallel circuits	10	Objectives 7&8
F.06	Draw parallel circuit and calculate circuit values	10	AS 10-12
F.07	Construct/analyze/install series-parallel circuits	10	Objective 9
F.09	Draw series-parallel circuits and calculate circuit values	10	AS 13-15
F.10	Set up and operate for DC circuits: – ohmmeter – voltage tester	 6 6	 JS 5&6 JS 5&6
G.01	Identify AC sources	11	FA
G.02	Analyze and apply principles of transformers to AC	11	Objectives 7-10
G.05	Construct/analyze/install polyphase circuits	11	Objective 11
G.06	Troubleshoot polyphase circuits	6	JS 7
G.08	Test capacitors in an AC circuit	11	AS 1&2
G.15	Set up and operate for AC circuits – volt amp meter – ohmmeter –voltage tester	 6/11 6 6	 JS 8&9/Objective 17 JS 5&7 JS 5&7
H.01	Demonstrate knowledge of Article 90	7	AS 1
H.02	Demonstrate knowledge of Article 100	7	AS 3
I.01	Calculate and balance the total load per phase	11	Objective 17
I.03	Calculate individual circuits	13	AS 7
I.04	Calculate the load in volt-amps and load current in amps	11	AS 1
I.07	Perform transformer and motor calculations	13	AS 16
I.08	Calculate voltage drop	11	AS 2

Duty/Task Crosswalk

Skill Code	Skill Description	Unit #	Specific Reference
I.09	Calculate conductors – de-rating – correction factors	13/17 13 13/15	AS 2/Objectives 7&8 AS 5&6 AS 3&4/AS 1
I.11	Calculate over-current protection	15	AS 1, JS 1
I.12	Perform calculations using Ohm's Law	9 10	Objectives 9-15, AS 2-5 AS 1, 2, 3, 6, 7, 8, 11, 16
J.02	Install main service panels	16	AS 2
J.04	Install main service disconnects	16	AS 1
J.05	Install circuit breakers in panels	16	AS 2
K.02	Install recessed fixture housings in ceilings	17	JS 7
K.03	Install bar-hanger mounted box	11/17	JS 1-4/JS 7
K.05	Install flush mount switch and outlet box in – lathe and plaster wall – paneled wall – masonry wall	 17 17 17	 JS 1-3 JS 4 JS 5&6
K.07	Install octagon outlet box	11/17	JS 1-4/JS 7
L.03	Rough-in circuits and other raceways in conduits	17	AS 1
L.05	Connect circuits to circuit breaker panels	16	JS 1&2
L.06	Rough-in circuits to outlet boxes	16	JS 3
L.07	Rough-in cables between existing boxes and newly installed boxes	17	JS 8-10
L.08	Rough in a circuit for an outlet controlled with – three-way switches and four-way switches – feed to the device box	11 11 11	Objective 18 JS 3&4 JS 1&2
L.09	Rough-in low-voltage circuits – door chime system	14	JS 1
L.10	Rough-in cable for general purpose branch circuits – receptacle outlet	16	JS 3
L.11	Make splices – using mechanical-type connectors – wire nuts	13 12 13	Objective 4 JS 1, 2, 4, 5 JS 4
L.13	Make terminations	13	JS 3
L.15	Install panels and subpanels	16	JS 2
L.20	Install conduits, cables, raceways, and equipment	13	Objective 10
L. 22	Rough-in thermostat wiring	13	Objectives 5-8
N.20	Install smoke and CO detectors	14	JS 2
P.02	Install wireway – lay-in – underfloor	17 17 17	Objectives 3-5 JS 8 & 10 JS 9

Skill Code	Skill Description	Unit #	Specific Reference
T.02	Troubleshoot/install/connect/replace door chime systems	14	AS 1, JS 1
T.05	Troubleshoot/install connect/repair/replace emergency warning systems – fire	14	AS 2, JS 2
U.02	Demonstrate appropriate interpersonal skills	All	
U.03	Maintain self-esteem in self and others	All	
U.04	Recognize the importance of team work and participate as a team member	All	
U.05	Maintain professional respect for co-workers and supervisor	All	
U.06	Demonstrate professionalism	All	
U.07	Practice critical thinking skills to workplace situations	All	
U.08	Maintain satisfactory attendance	All	
U.10	Function within the organizational structure	All	
U.11	Cooperate with co-workers in the completion of assignments	All	
U.12	Practice self-management (time management) techniques	All	
U.13	Practice deductive and inductive reasoning skills	All	
U.15	Employ listening skills	All	
U.16	Compose written communication legibly using correct grammar, spelling, and format	1 2 12 13 14	FA, AS 1-2 AS 4 AS 10 FA FA
U.17	Demonstrate ability to interpret and follow written directions and information	All	
U.18	Demonstrate ability to interpret and follow oral directions	All	
U.19	Use job-related terminology, symbols, and abbreviations	All	
U.21	Use effective communication techniques	All	
U.22	Use verbal and non-verbal communication techniques	All	
U.23	Apply behavior management techniques to workplace	All	
U.24	Identify personal and work related goals and monitor progress – professional goals	1 14	FA, AS 1-2 FA
U.25	Respond to compliments, complaints, conflicts, and criticism appropriately	All	

Skill Code	Skill Description	Unit #	Specific Reference
U.27	Retrieve, recognize, and calculate common statistical formulas		
	– addition, subtraction, multiplication, and division of		
	– whole numbers	4	AS 1-4
		8	AS 1
		9	AS 2-5
		10	AS 1-16
		11	AS 1&2
		13	AS 2, 3, 5, 6
		15	AS 1
		17	AS 1
	– fractions	4	AS 5-9
	– decimals	4	AS 10-13
		7	AS 6
		9	AS 2, 4, 5
		10	AS 8, 9, 12, 14, 16
		11	AS 1&2
		13	AS 2-6
		15	AS 1
		17	AS 1
	– percentages	4	AS 14&15
		15	AS 1
	– measurements	5/6	AS 1/AS 1
	– use of calculator	10	AS 1-15
	– basic geometry	6	AS 1
	– application of formulas	4	AS 16
	–word problems	2	AS 1, 4
		4	AS 1-4, 7-13, 15
		6	AS 1
		7	AS 4&5
		9	AS 5
		10	AS 1-3
		11	AS 1&2
		15	AS 1
		16	AS 1
		17	AS 1
U.28	Demonstrate negotiation skills		
	– solve everyday human relations problems	All	
U.29	Demonstrate leadership skills		
	– employ leadership skills	All	
U.30	Demonstrate career development skills		
	– investigate an occupation	1	FA, AS 1
	– explore career opportunities	1	AS 2
	– compare career options	1/14	AS 1/FA

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 1: Occupational Introduction

1. Definitions of *NEC* and occupation
2. Major purposes of the *NEC*
3. Areas the *NEC* is intended to cover
4. Areas the *NEC* is not intended to cover
5. Job responsibilities of electrical workers
6. Desirable physical abilities of electrical workers
7. Employment opportunities in the electrical field
8. Occupation hazards related to electrical work
9. Electrical trade organizations and their descriptions
10. Code compliance
11. Investigate careers associated with the electrical trade
12. Interview an electrical worker
13. Compare employment opportunities in the electrical field

Unit 2: General Safety and First Aid

1. Terms and definitions
2. Guidelines for dressing safely on the job
3. General job and shop safety rules
4. Shop conditions that should be reported
5. OSHA's role in workplace health and safety
6. Terms associated with fall protection systems
7. Fall protection systems
8. Terms associated with confined space entry
9. Responsibilities concerning confined space entry
10. Respirator requirements
11. Hazardous cleaners and lubricants
12. Storage of hazardous materials
13. Common hazardous materials found at the job site

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: General Safety and First Aid (continued)

Related Information: What the Student Should Know

14. Purposes of material safety data sheets (MSDS)
15. Ways hazardous materials can enter the body
16. Colors of the safety color code and their uses
17. Safety tags with their color coding
18. Components of the fire triangle
19. Types of fires and their classifications
20. Types of fire extinguishers and their uses
21. Fire extinguisher general operating instructions that follow the letters P-A-S-S
22. Causes of back injuries and their contributing factors
23. Guidelines for lifting and moving items safely
24. Guidelines for preventing slips, trips, and falls
25. Rules of using ladders safely
26. Safety guidelines for using scaffolds
27. Safety guidelines for using power lifts
28. General steps for handling any emergency situation
29. General guidelines for first-aid emergencies
30. Basic first aid procedures for various emergency situations

Application: What the Student Should Be Able to Do

31. Locate material safety data sheets
32. Draw a layout of your school shop and apply the safety color code
33. Interpret portable fire extinguisher symbols
34. Identify and correct safety violations
35. Operate a fire extinguisher
36. Lift a heavy object properly
37. Place and climb a ladder safely

Unit 3: Electrical Safety

1. Terms and definitions
2. Major causes of electrical accidents
3. Basic electrical safety practices
4. Electrical fire prevention practices
5. Safety practices around live circuits
6. Proper grounding
7. Importance of the third wire
8. Ground-fault circuit-interrupters

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 3: Electrical Safety (continued)

9. Instances when lockout devices should be used
10. Electrical shock
11. Facts about treating a victim of electrical shock

12. Control electrical hazards
13. Identify and describe safety violations
14. Solve problems concerning electrical safety practices

Unit 4: Related Math and Measuring

1. Terms and definitions
2. Symbols used in math problems
3. Place values of a whole number
4. Adding whole numbers
5. Subtracting whole numbers
6. Multiplying whole numbers
7. Dividing whole numbers
8. Types of fractions
9. Reducing fractions to lowest terms
10. Converting fractions and mixed numbers
11. Adding fractions
12. Subtracting fractions
13. Multiplying fractions
14. Placing values for a decimal number
15. Adding decimal numbers
16. Subtracting decimal numbers
17. Multiplying decimal numbers
18. Dividing decimal numbers
19. Converting fractions and percentages
20. Solving percentage problems
21. Terms used in geometry and their definitions
22. Types of geometric figures and their descriptions
23. Units of measure and their equivalents
24. Calculating area of geometric figures
25. Metric prefixes and their values
26. English-metric conversion

27. Add whole numbers
28. Subtract whole numbers
29. Multiply whole numbers
30. Divide whole numbers
31. Reduce fractions to lowest terms
32. Convert fractions and mixed numbers
33. Add fractions
34. Subtract fractions
35. Multiply fractions
36. Add decimal numbers
37. Subtract decimal numbers
38. Multiply decimal numbers
39. Divide decimal numbers
40. Convert fractions and percentages
41. Solve percentage problems
42. Calculate area of geometric figures

Unit 5: Hand Tools

Related Information: What the Student Should Know

1. Terms and definitions
2. Common hand tools used in the electrical field
3. Electricity-specific hand tools used in the electrical field
4. Common hand tools and their uses
5. Electricity-specific hand tools and their uses
6. Factors to consider when purchasing hand tools
7. Rules for care of various hand tools

Application: What the Student Should Be Able to Do

8. List and price electrician's tools
9. Measure objects using a tape measure
10. Clean and lubricate an adjustable hand tool
11. Use a cutting/crimping tool
12. Adjust wire strippers
13. Set up and use a hacksaw to cut conduit
14. Ream and thread rigid conduit
15. Bend EMT conduit
16. Use a knockout punch
17. Use a hole saw

Unit 6: Powered/Specialty Tools and Equipment

1. Terms and definitions
2. Common powered tools
3. Common powered tools and their uses
4. Typical powered/specialty equipment
5. General safety rules for using powered/specialty equipment
6. Parts of a hydraulic knockout set
7. Specific safety rules for using hydraulic knockout sets
8. Parts of a hydraulic pipe bender
9. Specific safety rules for using hydraulic pipe benders
10. Parts of a polyvinylchloride (PVC) heater and blanket
11. Specific safety rules for using polyvinylchloride heaters and blankets
12. Parts of a power drill
13. Specific safety rules for using power drills
14. Parts of a power cable puller
15. Specific safety rules for using a power cable puller

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 6: Powered/Specialty Tools and Equipment (continued)

Related Information: What the Student Should Know

16. Parts of portable and table bandsaws
17. Specific safety rules for using portable and table bandsaws
18. Parts of a dieless hydraulic crimper
19. Specific safety rules for using hydraulic crimpers
20. Parts of a hammer drill
21. Specific safety rules for using hammer drills
22. Parts of a core drilling machine
23. Specific safety rules for using a core drilling machine
24. Parts of a portable power threader
25. Specific safety rules for using a portable power threader
26. Typical scale used in the electrical industry
27. Typical electrical test equipment

Application: What the Student Should Be Able to Do

28. Determine dimensions on a drawing using an architects scale
29. Use a hydraulic knockout punch
30. Bend a 90-degree stub using a hydraulic pipe bender
31. Make offset and 90-degree bends using an electrical PVC heater
32. Cut, ream, and thread rigid conduit with a power threader
33. Measure resistance using a VOM
34. Measure DC voltages using a VOM
35. Measure AC voltages using a VOM
36. Measure amperage using a clamp-on ammeter
37. Determine the current of a multiple loop using a clamp-on ammeter
38. Check conductor insulation with a megger

Unit 7: Using Trade Information

Related Information: What the Student Should Know

1. Terms and definitions
2. Purpose of the *National Electrical Code*
3. Factors that are not covered by the *National Electrical Code*
4. Intent of the *National Electrical Code* regarding mandatory enforcement
5. *National Electrical Code* chapter numbers and their areas of application
6. Sequence of organizational components of *National Electrical Code* information
7. Steps for finding information in the *National Electrical Code*

Application: What the Student Should Be Able to Do

8. Using the *National Electrical Code*
9. Use the *National Electrical Code* index to answer questions about Code sections
10. Using the *National Electrical Code* title page, table of contents, and introduction to answer questions
11. Use the *National Electrical Code* first chapter to define terms
12. Use the *National Electrical Code* to answer general questions related to residential wiring.
13. Use the *National Electrical Code* to locate allowable ampacities for various conductors.
14. Use the *National Electrical Code* to interpret conduit fill tables
15. Find information in the *National Electrical Code*

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 8: Basic Equipment

1. Terms and definitions
2. Classes of outlet boxes used in electrical wiring
3. Information needed to calculate boxfill
4. Types of enclosures and their conditions for use
5. Purposes of controller enclosures
6. Types of devices commonly used in electrical wiring
7. Types of covers and plates used in electrical wiring
8. Supports and anchors commonly used in electrical wiring
9. Screws, bolts, and nuts commonly used in electrical wiring
10. Classes of box mounting devices for steel structures
11. Determine the correct number of conductors for boxfill
12. Install outlet boxes on wood studs on a framed wall
13. Install outlet boxes on steel structures and rods using caddy clips
14. Install outlet boxes on steel studs using caddy metal stud clips for switch boxes
15. Install masonry boxes in a block wall

Unit 9: Basic Theory

1. Terms and definitions
2. Principles of electron flow
3. Basic sources of electrical generation
4. Distribution of electricity
5. Electrical schematic symbols
6. Diagrams and schematics
7. Letters and their terms
8. Ohm's law
9. Ohm's law in wheel expression
10. Uses of Ohm's law
11. Unit of measure formula for Ohm's law
12. Ohm's law for power
13. Ohm's law for power in wheel expression
14. Uses of Ohm's law for power
15. Unit of measure formulas from Ohm's law for power
16. Draw a diagram of the power distribution supplying your school shop or home
17. Solve problems for unknown voltages
18. Solve problems for unknown amperage
19. Solve problems for unknown resistances and wattages
20. Solve problems for an unknown quantity

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 10: DC Circuits

1. Terms and definitions
2. Applications of DC circuits
3. Application of Ohm's law to direct current
4. Characteristics of series circuits
5. Three basic formulas for Watt's law
6. Kirchoff's voltage law
7. Characteristics of parallel circuits
8. Kirchoff's current law
9. Characteristics of series-parallel circuits

10. Solve problems for unknown current
11. Solve problems for unknown resistance
12. Solve problems for unknown voltage
13. Determine total resistance in series circuits
14. Determine unknown resistance values in series circuits
15. Solve problems for unknown current in series circuits
16. Solve problems for unknown resistance in series circuits
17. Solve problems for unknown voltage in series circuits
18. Apply Kirchoff's voltage law to series circuits
19. Solve problems for unknown resistance in parallel circuits
20. Solve problems for unknown current in parallel circuits
21. Apply Kirchoff's current law to parallel circuits
22. Solve problems for unknown resistance in series-parallel circuits
23. Solve problems for unknown voltage in series-parallel circuits
24. Solve problems for unknown current in series-parallel circuits
25. Compute power using Ohm's law

Unit 11: AC Circuits

1. Terms and definitions
2. Principles of AC theory
3. Principles of induction
4. Inductance characteristics
5. Factors affecting inductors
6. Power characteristics in inductive circuits

Instructional/Task Analysis

Unit 11: AC Circuits (continued)

Related Information: What the Student Should Know

7. Transformer characteristics
8. Classes of transformers
9. Single-phase transformer connections
10. Other transformer connections found in electrical trades
11. Power in three-phase circuits
12. Testing for polarity
13. Capacitance characteristics
14. Types, ratings, and common defects of capacitors
15. Capacitive AC RC circuits
16. Inductive AC circuits
17. Power characteristics in AC circuits
18. Basic switching circuits used in electricity

Application: What the Student Should Be Able to Do

19. List facts about producing AC electricity
20. Solve RC and RL circuit problems
21. Solve power factor problems
22. Draw a diagram of a single-pole switch on a light
23. Draw a diagram of two three-way switches on a light
24. Draw a diagram of two three-way switches and a four-way switch on a light
25. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the switch box
26. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box
27. Wire a three-way switching situation with the supply line entering a single lighting outlet
28. Wire a four-way switching situation with the supply line entering the lighting outlet box

Unit 12: Wiring Methods

Related Information: What the Student Should Know

1. Terms and definitions
2. Wiring methods found in electrical trades
3. Wiring methods and their common applications

Application: What the Student Should Be Able to Do

4. Identify environments and structures requiring electrical wiring installations
5. Reference the *National Electrical Code* to identify uses of wiring methods
6. Install a set-screw conduit fitting
7. Install a compression-type conduit fitting
8. Prepare MC cable for termination
9. Install a connector onto liquidtight flexible metallic conduit
10. Install a connector onto rigid nonmetallic conduit

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 13: Conductors

1. Terms and definitions
2. Factors that determine conductor type and size
3. Characteristics of good connections
4. Types of connectors, terminals, and lugs
5. Wire insulation and its characteristics
6. Types of insulation, its characteristics, applications, and code letters
7. Conductors commonly found in electrical wiring
8. Color codes for conductors
9. Means of identifying "grounded" and equipment "grounding" conductors
10. Types of cable and their uses
11. Cords and their conductors
12. Report on an electrical fire
13. List conductors in order, by size
14. Calculate ampacity of conductors, given insulation and conductor type
15. Calculate corrected ampacity of conductors
16. Select conductors for various ampacities and temperatures
17. Calculate ampacity of conductors, given number of conductors in raceway
18. Calculate ampacity and conductor sizes for specific types of loads
19. Select cords for various applications
20. Select proper types of insulation
21. Install cord on utilization equipment
22. Use a fish tape to install wire in conduit
23. Prepare an aluminum conductor for termination
24. Splice solid conductors using a wire nut

Unit 14: Low Voltage Wiring

1. Terms and definitions
2. Parts of a low voltage wiring system
3. Process that takes place during a low voltage lighting circuit off/on cycle
4. Process that takes place during the energizing of a chime circuit
5. Manual fan switching circuit
6. Thermostat system switch in the cool position and the fan switch on auto
7. Thermostat system switch in the heat position and the fan switch on auto
8. Anticipator circuits on low voltage thermostats
9. Communication circuits and their characteristics
10. Smoke and fire alarm systems
11. Garage door opener operation
12. List licensing requirements for low voltage wiring systems
13. Draw a wiring diagram indicating the proper connection for bell circuit equipment
14. Draw a wiring diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors
15. Wire a two-button chime circuit
16. Wire two interconnecting smoke detectors

Instructional/Task Analysis

Unit 15: Overcurrent Protection

Related Information: What the Student Should Know

1. Terms and definitions
2. Types of overcurrent protective devices
3. Operation of a single-element fuse
4. Operation of a dual-element, time-delay fuse
5. Types of circuit breakers and their operation
6. Requirements for fuses of less than 600 volts
7. Requirements for circuit breakers of less than 600 volts
8. Installations that require GFCI protection
9. Installations that require AFCI protection

Application: What the Student Should Be Able to Do

10. Identify overcurrent protective devices
11. Calculate conductor and fuse sizes
12. Test cartridge fuses

Unit 16: Load Centers and Safety Switches

Related Information: What the Student Should Know

1. Terms and definitions
2. Types of safety switch enclosures
3. Safety switch system configurations
4. Types of load centers and enclosures
5. Common load center accessories and their uses
6. Parts of a fusible, single-phase load center
7. Parts of a breaker load center
8. Common panel bus configurations

Application: What the Student Should Be Able to Do

9. Safety rules for wiring near load centers and safety switches
10. Determine cost of load center construction
11. Using the *NEC*, answer questions related to load centers
12. Install a safety switch
13. Wire a load center or breaker panel
14. Wire a receptacle circuit to a load center

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 17: Existing Structures

1. Terms and definitions
2. Construction members common in existing structures
3. Common routes for new cable installations
4. Possible methods for getting cable through or around construction members
5. Wall or ceiling compositions that may be found in an existing structure
6. Conditions for using optional calculations for additional loads to existing installations 7. Exceptions to the *NEC* requirements for support of flexible metal conduit
8. Steps for determining the number of conductors allowed in a conduit, based on cross-sectional area
9. Replacement of receptacles in existing structures
10. Equipment grounding connections in existing structures
11. Determine the number of conductors allowed to be added to an existing conduit
12. Install a metallic box with dry-wall grips in a plasterboard wall
13. Secure a box with dry-wall supports
14. Install a plastic box with dry-wall grips in a plasterboard wall
15. Install a box in a paneled wall
16. Install a box in a concrete block wall
17. Install a box in a brick wall
18. Install a box in a ceiling with an accessible attic
19. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind base board
20. Install cable between an existing box and a newly installed box, using an underfloor crawl space
21. Install cable between an existing box and a newly installed box, using attic space

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each focus assignment, assignment sheet, and job sheet.

A matrix for each of the nine broad skill areas has been included in this addition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000,* a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want,* a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL) and other national and state sources.

Each of the nine broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, and social studies—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

Basic Skills Icons and Classifications

When an activity involving one of these basic skills is identified, the corresponding icon is placed in the left-hand margin of the focus assignment, assignment sheet, and job sheet. Skills training is further defined by classifying specific skills that are required. (See skills list that may be found on each basic skills matrix.)

Example:

Unit 2 **General Safety and First Aid**

Objective 32

Assignment Sheet 1—Interpret a Material Safety Data Sheet

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Directions followed	_____
• All answers correct per Answers to Assignment Sheet 1	_____

Materials list

- Pen or Pencil

Basic Skills

Reading Writing Critical Thinking

Directions

Review the material in Objective 4 of the information sheet, and locate and study the information presented in Student Supplement 2, "Guidelines for Interpreting Material Safety Data Sheets."

Use the MSDS at the end of this assignment sheet to answer the following questions. Write your answers on the blanks provided below each item.

MSDS Gel Graffiti®

a. What is this product used for?

____

b. What is the main ingredient in this product?

____

c. What does this product look like?

____

d. What percentage of this product is volatile (capable of exploding)?

____

MAVCC—*Basic Wiring* Page 2–53

BASIC SKILLS MATRIX

Reading Skills

UNITS OF INSTRUCTION	Reading Comprehension									Research/Reference								Functional Reading					
	Gain factual information	Distinguish fact, opinion and inference	Recognize stereotyping and bias	Recognize propaganda	Analyze cause and effect	Draw conclusions	Make generalizations	React to written material	Apply word analysis techniques	Select useful resources	Locate resources	Find materials in library	Use standard references	Use in-book reference tools	Use audiovisual media	Use computer data base	Use magazines and newspapers	Interpret forms and records	Follow written instructions	Interpret graphics and symbols	Use content area vocabulary	Interpret abbreviations/acronyms	Read aloud
Unit 1.											X						X						
Unit 2.	X				X	X		X			X								X			X	
Unit 3.					X	X		X											X				
Unit 4.								X											X				
Unit 5.								X		X	X								X				
Unit 6.								X											X				
Unit 7.	X							X			X			X					X		X		
Unit 8.	X							X			X			X					X		X		
Unit 9.								X											X				
Unit 10.								X											X				
Unit 11.	X	X				X		X		X	X	X	X						X	X	X		
Unit 12.	X						X	X		X	X			X							X		
Unit 13.	X				X	X		X		X	X	X	X	X			X		X		X		
Unit 14.								X											X				
Unit 15.								X											X				
Unit 16.								X					X	X					X				
Unit 17.								X											X				

BASIC SKILLS MATRIX

Writing Skills

UNITS OF INSTRUCTION	Language		Composition								Research					Functional Writing						
	Use standard grammar, spelling, and capitalization	State ideas clearly	Use complete sentences	Develop preliminary outline	Use topic sentences	Use introductory/closing paragraphs	Compose reports	Compose essays	Proofread and edit	Construct graphics and symbols	Take notes	Use note cards	Create bibliography	Use footnotes	Outline material	Complete forms and records	Write instructions	Write letters	Write job applications	Write resumes	Use word processing	Use computer graphics
Unit 1.	X		X								X											
Unit 2.	X	X								X												
Unit 3.	X	X																				
Unit 4.																						
Unit 5.																						
Unit 6.																						
Unit 7.	X	X																				
Unit 8.																						
Unit 9.										X												
Unit 10.																						
Unit 11.	X	X	X							X	X											
Unit 12.	X	X	X	X	X																	
Unit 13.	X	X	X		X		X		X													
Unit 14.	X	X								X												
Unit 15.	X																					
Unit 16.	X																					
Unit 17.																						

BASIC SKILLS MATRIX

Math Skills

UNITS OF INSTRUCTION	Operation and Calculation														Math Application										
	Round off numbers	Estimate answers	Use scientific notations	Use exponential notations	Calculate with whole numbers	Calculate with fractions	Calculate with decimals	Convert whole numbers to fractions	Convert whole numbers to decimals	Solve numerical expressions	Solve formulae and equations	Obtain squares and square roots	Converts units of measure	Perform metric calculations	Solve word problems	Select/apply mathematical formula	Select/apply mathematical procedure	Use English and metric measures	Solve time/rate/distance problems	Solve ratio/proportion problems	Solve percent problems	Apply techniques of scaling	Apply algebra principles	Apply geometry principles	Apply trigonometry principles
Unit 1.																									
Unit 2.															X										
Unit 3.																									
Unit 4.					X	X	X	X	X						X		X							X	
Unit 5.																		X							
Unit 6.															X			X							
Unit 7.							X								X		X								
Unit 8.					X												X								
Unit 9.					X		X								X										
Unit 10.	X				X		X	X			X				X		X								
Unit 11.				X	X		X				X				X	X	X								
Unit 12.																									
Unit 13.					X		X																		
Unit 14.																									
Unit 15.					X		X								X		X								
Unit 16.															X										
Unit 17.					X		X								X										

BASIC SKILLS MATRIX

Math Skills (continued)

UNITS OF INSTRUCTION	Data Analysis and Display										Functional Math													
	Interpret charts and tables	Interpret graphs	Collect/record data	Apply sampling techniques	Apply principles of probability	Construct charts and tables	Construct graphs	Calculate statistics	Interpret statistics	Interpret plans/blueprints	Make measurements	Perform banking transactions	Make change	Solve practical problems	Calculate gross earnings	Solve income/expense problems	Prepare a budget	Calculate interest	Solve interest problems	Calculate sales tax	Determine income tax	Use calculator for computation	Use computer for computation	Use computer spreadsheets
Unit 1.																								
Unit 2.																								
Unit 3.																								
Unit 4.																								
Unit 5.											X													
Unit 6.											X													
Unit 7.																								
Unit 8.																								
Unit 9.																								
Unit 10.																						X		
Unit 11.																								
Unit 12.																								
Unit 13.																								
Unit 14.																								
Unit 15.																								
Unit 16.																								
Unit 17.																								

BASIC SKILLS MATRIX

Science Skills

	General Science									Life Science						
UNITS OF INSTRUCTION	Apply computing skills	Apply scientific method of inquiry	Conduct experiments	Investigate science ethics	Investigate science history	Investigate/apply economics in technology	Use scientific instruments	Investigate/apply technology	Collect specimens	Identify/classify living organisms	Investigate biological history of the earth	Investigate food chains, webs, pyramids	Investigate/apply principles of human development	Investigate/apply principles of genetics/heredity	Investigate/apply principles of anatomy/physiology	Investigate health issues
Unit 1.																
Unit 2.																
Unit 3.																
Unit 4.																
Unit 5.																
Unit 6.																
Unit 7.																
Unit 8.																
Unit 9.																
Unit 10.																
Unit 11.			X					X								
Unit 12.																
Unit 13.																
Unit 14.																
Unit 15.																
Unit 16.																
Unit 17.																

BASIC
SKILLS
MATRIX

Science Skills (continued)

UNITS OF INSTRUCTION	Physical Science					Earth Science										
	Analyze/classify matter	Investigate forms/changes of matter	Investigate forms/changes of energy	Investigate/apply chemical properties	Investigate/apply physical laws	Investigate physical characteristics of the earth	Investigate geological history of the earth	Investigate physical forces acting on the earth	Solve problems of longitude, latitude, and time zones	Investigate conservation of physical resources	Investigate conservation of living resources	Investigate issues of environmental impact	Apply science principles to environmental issues			
Unit 1.																
Unit 2.																
Unit 3.																
Unit 4.																
Unit 5.																
Unit 6.																
Unit 7.																
Unit 8.																
Unit 9.			X													
Unit 10.																
Unit 11.																
Unit 12.																
Unit 13.																
Unit 14.																
Unit 15.																
Unit 16.																
Unit 17.																

BASIC SKILLS MATRIX

Oral Communication Skills

UNITS OF INSTRUCTION	Oral Presentation									Listening				Interactive Communication									
	Make informative presentations	Make persuasive presentations	Present personal opinion/viewpoint	Use good speaking techniques	Select/use words effectively	Use effective body language	Present appropriate appearance	Integrate audio and/or visual materials into oral presentations	Adapt presentation to specific audience	Apply active listening skills	Distinguish fact, opinion, and inference	Draw conclusions/make generalizations	Analyze/identify point of view	Give/follow oral directions	Apply questioning techniques	Conduct/receive interviews	Analyze/apply nonverbal communication	Work effectively in a group	Communicate with clients/customers/patients	Communicate with co-workers	Communicate with supervisors	Communicate with professional colleagues/associates	Apply telephone etiquette
Unit 1.										X													
Unit 2.																							
Unit 3.																							
Unit 4.																							
Unit 5.																							
Unit 6.																							
Unit 7.																							
Unit 8.																							
Unit 9.																							
Unit 10.																							
Unit 11																							
Unit 12.																							
Unit 13.	X			X	X	X					X	X			X					X	X		
Unit 14.																							
Unit 15.																							
Unit 16.																							
Unit 17.																							

BASIC SKILLS MATRIX

Interpersonal or Relating Skills

UNITS OF INSTRUCTION	General Relating												Teamwork/Cooperation														
	Investigate/apply communication process models	Analyze/apply nonverbal communication	Investigate/apply cross-cultural communication	Interact with co-workers	Interact with supervisors	Interact with clients/customers/patients	Interact with professional colleagues/associates	Interact with family/friends	Participate in group activities	Participate in industrial relations/functions	Identify personal values/attitudes	Apply information to life experiences	Identify values/attitudes	Identify needs/drives	Select/apply appropriate behavior	Investigate/identify personal styles	Investigate/identify group/corporate climate	Give/receive feedback	Identify hidden purposes	Investigate/apply group dynamics	Control undesirable/inappropriate behavior	Resolve conflicts	Clarify goals/objectives	Devise "win/win" situations	Build consensus	Generate ideas	Present point of view
Unit 1.									X																		
Unit 2.				X														X							X	X	
Unit 3.																											
Unit 4.																											
Unit 5.																											
Unit 6.																											
Unit 7.																											
Unit 8.																											
Unit 9.																											
Unit 10.																											
Unit 11.																											
Unit 12.																											
Unit 13.																											
Unit 14.																											
Unit 15.																											
Unit 16.																											
Unit 17.																											

BASIC SKILLS MATRIX

Interpersonal or Relating Skills (continued)

Leadership/Influence

UNITS OF INSTRUCTION	Analyze/apply leadership styles	Analyze/apply management styles	Obtain confidence of others	Develop esteem in self/others	Persuade others	Analyze/apply motivation techniques	Provide positive coaching																		
Unit 1.																									
Unit 2.																									
Unit 3.																									
Unit 4.																									
Unit 5.																									
Unit 6.																									
Unit 7.																									
Unit 8.																									
Unit 9.																									
Unit 10.																									
Unit 11.																									
Unit 12.																									
Unit 13.																									
Unit 14.																									
Unit 15.																									
Unit 16.																									
Unit 17.																									

BASIC SKILLS MATRIX

Critical Thinking Skills

Cognitive Activities

UNITS OF INSTRUCTION	Collect/record information	Identify critical elements/issues	Define a problem	Identify underlying causes	Apply a problem-solving model	Analyze/synthesize information	Identify/analyze underlying assumptions	Draw conclusions	Predict results/outcomes	Identify/evaluate consequences	Identify/develop alternatives	Evaluate alternatives	Select an alternative	Devise a solution	Create a finished product	Apply intuitive thinking techniques	Transfer knowledge/training to new situations	Apply new technology	Develop an action plan	Evaluate results/outcomes
Unit 1.																				
Unit 2.	X	X	X	X		X		X						X						
Unit 3.		X	X	X		X		X									X		X	
Unit 4.																				
Unit 5.											X	X	X							
Unit 6.																				
Unit 7.																				
Unit 8.																				
Unit 9.																				
Unit 10.																				
Unit 11.																				
Unit 12.																				
Unit 13.																				
Unit 14.																				
Unit 15.																				
Unit 16.																				
Unit 17.																				

BASIC SKILLS MATRIX

Employability Skills

UNITS OF INSTRUCTION	Job Search/Selections Analyze personal occupational aptitudes/ preferences	Investigate employment prospects of a career field/occupation	Investigate training requirements for a career field/occupation	Investigate benefits of a career field/ occupation	Compare/evaluate career options	Develop personal career path	Locate appropriate jobs	Analyze duties/requirements/benefits of specific job	Job Acquisition/Development Master specific job task/procedure	Complete job-related applications	Write a letter of application	Write personal resume	Interview for a job	Apply business etiquette	Practice good work habits/attitudes	Practice good personal presentation	Develop self confidence/esteem	Develop effective leadership	Deal effectively with supervisors	Deal effectively with co-workers	Deal effectively with professional colleagues/associates	Deal effectively with customers/ clients/patients
Unit 1.		X	X	X	X		X		X					X	X	X	X		X	X		
Unit 2.									X						X		X		X			
Unit 3.																						
Unit 4.																						
Unit 5.								X	X						X		X					
Unit 6.									X						X		X					
Unit 7.																						
Unit 8.									X						X		X					
Unit 9.																						
Unit 10.																						
Unit 11.									X						X		X					
Unit 12.									X						X		X					
Unit 13.									X						X		X					
Unit 14.			X		X			X	X						X		X					
Unit 15.									X						X		X					
Unit 16.									X						X		X					
Unit 17.									X						X		X					

BASIC SKILLS MATRIX

Social Studies Skills

UNITS OF INSTRUCTION	Information Analysis						Social Studies Application															
	Collect/record data	Interpret graphical information	Construct graphical information	Interpret maps/globes	Interpret statistical information	Analyze/interpret demographic information	Investigate/apply U.S. history	Investigate/apply world history	Investigate/apply U.S. geography	Investigate/apply world geography	Investigate/apply principles of government/politics	Investigate/apply principles of economics	Investigate/apply principles of ethics	Investigate/apply principles of psychology	Investigate/apply principles of sociology	Investigate/apply cross-cultural studies					
Unit 1.																					
Unit 2.																					
Unit 3.																					
Unit 4.																					
Unit 5.																					
Unit 6.																					
Unit 7.																					
Unit 8.																					
Unit 9.																					
Unit 10.																					
Unit 11.																					
Unit 12.																					
Unit 13.																					
Unit 14.																					
Unit 15.																					
Unit 16.																					
Unit 17.																					

BASIC SKILLS MATRIX

Social Studies Skills
(continued)

Functional Social Studies

UNITS OF INSTRUCTION	Practice responsible personal economics	Prepare a personal budget	Use credit responsibly	Practice good work ethics	Participate in industrial relations	Interact with people of different races/cultures	Investigate/participate in government	Investigate/apply American legal practices	Select/use sources of information on current events	Analyze current events	Analyze consumer issues	Analyze social issues	Analyze conservation/ecology issues	Analyze social impact of science/technology	Analyze economic impact of science/technology						
Unit 1.																					
Unit 2.																					
Unit 3.																					
Unit 4.																					
Unit 5.																					
Unit 6.																					
Unit 7.																					
Unit 8.																					
Unit 9.																					
Unit 10.																					
Unit 11.																					
Unit 12.																					
Unit 13.																					
Unit 14.																					
Unit 15.																					
Unit 16.																					
Unit 17.																					

Tools, Equipment, and Materials List

- Ammeter – clamp-on
- Anchors, plastic
- Antioxidant
- Appliance – small, fixed
- Anti-short bushing
- Arbor
- Arc-fault circuit interrupter (AFCI)
- Architect's scale
- Bar hanger
- Battery
- Belt – back support
- Blueprint – construction
- Bolts – various sizes
- Boxes – various sizes
    - Metallic
    - Non-metallic
    - Square
    - Octagonal
    - Handy
    - Outlet
    - Receptacle
    - Switch
    - Masonry
    - One-gang
    - Two-gang
    - Handy
- Box clips
- Box tins
- Brace
- Breaker index sheet
- Breakers, circuit – various currents
- Cable – various lengths
    - Non-metallic
    - Non-metallic sheathed
    - EMT
    - ENT
    - MC
    - SE
    - Bell wire
- Carriage lever accessory
- Chime
- Chisel – concrete
- Clamps – rod-hanger, cable
- Cleaning cloth
- Clips
    - Stud
    - Caddy
    - MF
- Compound – wire pulling
- Conductors – various lengths
    - Copper
    - Aluminum
    - Copper clad aluminum
- Conduit bender
- Conduit – various lengths
    - PVC
    - Rigid metallic
    - Intermediate metal
    - Electrical metallic
    - Liquidtight
    - Sealtight
    - EMT
    - Flexible metal
- Connectors
    - EMT, compression type
    - Set-screw
    - MC
    - Sealtight
    - Liquidtight
    - PVC
    - Wire
    - Non-metallic sheathed
- Copper wire – insulated
- Couplings
    - Set-screw
    - PVC
    - Compression-type
- Cutting-crimping tool
- Cutting oil
- Dies
- Die head accessory
- Door bell buttons
- Drill
- Drill bits
    - Wood
    - Metal
    - Masonry
    - Ship auger

Tools, Equipment, and Materials List

- Drill motor
- Drop chain
- Drop cloth
- Drop light and cord
- Dry wall grips – with and without ears
- Duplex receptacle
- Dust mask
- EMT bender
- Extension cord and connector
- Fasteners
- Fish tape – steel
- Fish wire
- Flat bar
- Fuses – various
- GFCI – portable
- Gloves
  - Safety
  - Rubber
  - Insulated
- Hacksaw and blade
- Hammers
  - Ball peen
  - Electrician's
- Hanger bar
- Header board
- Heat-cool thermostat
- Heating unit
- Incandescent bulb – 120V
- Insulated wire
- Ladders
  - Extension
  - Step
- Level
- Lighting relay – 24V
- Light socket
- Lighting switches – low voltage
- Live disconnect
- Load center
- Megger
- Metal tapping screws
- Mortar
- Multimeter
- Nails – various sizes and uses
- Oil
- Oiler
- Pail
- Paint brush
- Pencil
- Pipe – steel
- Pipe cutter
- Pipe reamer – hand and power, accessory
- Pipe vise
- Plaster rings
- Plasterboard
- Pliers
  - Long nose
  - Lineman's
  - Groove joint
- Portable fire extinguisher
- Pouch tools
- Power supply – 120V
- Power threader and stand
- Punch
  - Knockout, hydraulic
  - Center
- PVC
  - Glue
  - Heater
  - Cutter
  - Solvent
- Resistors – various
- Safety glasses
- Saw – keyhole
- Screwdriver – flat blade
- Sheet metal screws
- Shop towels
- Smoke detectors - 2
- Solid insulated conductor
- Solvent and tray
- Sponge
- Staples
  - Romex
  - Cable
  - Standard
- Steel pipe
- Step down transformer – 120V-24V
- String
- Stud clips
- Switch
  - Single pole
  - Safety
  - 3-way
  - 4-way
- Tape
  - Masking
  - Electrical
  - Phasing
- Tape measure

- Test leads
- Tool carriage accessory
- Torpedo level
- Touchup paint
- Transformer – 16V
- Trouble light and bulb
- Vise
- Volt-ohmmeter
- Walls
  - Plasterboard
  - Steel
  - Concrete block
  - Stud
  - Brick
  - Paneled
- Water hose
- Whisk broom
- Wire brush
- Wire lugs
- Wire nuts
- Wire strippers
  - Adjustable
  - Fixed
- Wrench – adjustable
- Wood scraps
- Wood screws
- Work board

Unit 1 Occupational Introduction

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1–3
Written Test 1–7
Answers to Written Test 1–11

Teacher Supplement

1—Career Listing 1–13

Student Components

Student Page

Learning Activities Sheet 1–3
Objective Sheet 1–5
Information Sheet 1–7

* Focus Assignment

List Careers Associated with the Electrical Trade 1

* Assignment Sheets

1—Interview an Electrical Worker 3
2—Compare Employment Opportunities in the Electrical Field 5

* Focus Assignment and Assignment Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Upon completion of the Focus Assignment, have students begin to call out the occupations they listed. As they do, write them on the chalkboard and discuss their selections as well as your own (see Teacher Supplement 1)
- Invite local contractors, electricians, and inspectors to class to discuss employment opportunities and their respective job responsibilities.
- Discuss the licensing requirements for apprentices, journeyman, and contractors.
- Visit local construction sites. Have students write summary reports of their observations.
- Visit a local company or manufacturer that employs electrical maintenance workers. Before the visit, have the students prepare questions they want to ask.
- Upon completion of Assignment Sheet 1, have students share the information they obtained during their interviews with electrical workers.
- Upon completion of Assignment Sheet 2, have students compare employment opportunities and compile a list of local employment opportunities.

Evaluation

- Make copies of the written test. Add or modify test items as needed.

  The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

Suggested Activities

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Electricity Occupations Curriculum Guide*. Springfield, IL: Illinois Office of Education/Division of Vocational and Technical Education.
- Taylor, Mark. Residential Wiring. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Supplemental Resources

Electronic Media

- Software—Introduction to Electricity. Shopware Educational Systems Department KL-4, 101 Hill Road, Aberdeen, WA 98520-7302.
- Internet (see Objective 9, Student Information Sheet)

Written Test

Name ______________________________

Date ______________________________ Score______

Objective 1

Define *NEC* and occupation.

a. *NEC*— ______________________________

b. Occupation— ______________________________

Objective 2

State three major purposes of the *NEC*.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 3

List three areas the *NEC* is intended to cover.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

Objective 4

List three areas the *NEC* is NOT intended to cover.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

Objective 5

List six job responsibilities of electrical workers.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Objective 6

Select from the following list, desirable physical abilities of electrical workers. Write an "X" in the blank before each correct statement.

_____ a. Ability to lift at least 100 pounds

_____ b. Ability to work with hands in a skillful manner

_____ c. Ability to see perfectly

_____ d. Ability to distinguish colors

_____ e. Ability to work in confined areas such as crawl spaces and attics

_____ f. Ability to work on ladders and scaffolds

Objective 7

List eight employment opportunities in the electrical field.

a. ______________________________

b. ______________________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

Objective 8

Describe four occupational hazards related to electrical work.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Objective 9

Match electrical trade organizations with their descriptions. Write the correct numbers in the blanks.

1. IEC (Independent Electrical Contractors)
2. IBEW (International Brotherhood of Electrical Workers)
3. AIECA (American Independent Electrical Contractors Association)
4. AGC (Associated General Contractors)
5. NECA (National Electrical Contrators Association)

_____ a. An organization of independent electrical contractors or "merit shop" contractors; provides training of the employees of its members

_____ b. An organization of electrical contractors that employ primarily IBEW electricians and apprentices

_____ c. An organization of electrical contractors that employ non-union personnel

_____ d. An organization of general contractors in the construction industry; provides training to employees of its member in all construction trade areas

_____ e. A trade union of workers engaged in electrical installations and maintenance; provides training and placement for its members

Written Test

Objective 10

Complete statements about *Code* compliance. Circle the correct word.

a. The electrical contractor and journeyman electrician are (**obligated, urged**) to comply with local, state, and national codes.

b. Failure to comply could result in the loss of property and (**equipment, lives**).

c. Failure to comply can result in the revocation of (**title, license**) or permits.

d. Failure to comply can result in the loss of (**livelihood, membership**).

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. ***NEC**—National Electrical Code*; a publication developed by the a National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity

b. **Occupation**—The vocation or activity at which a person works

Objective 2

Answer should include any three of the following:

a. The *NEC* sets the minimum standards for electrical work in general and specific instances.
b. The purpose of the *NEC* is the "practical safeguarding of persons and property from hazards arising from h use of electricity."
c. The *NEC* is considered necessary for safety; compliance with the *Code* will result in an installation that is free from hazard; this does not guarantee efficiency or adequacy for future expansion.
d. The *NEC* is not intended to be a design manual or an instructional manual for untrained individuals.
e. The *NEC* protects the consumer from dangerous installations of electrical wiring and serves as a means for testing and protecting those who install said wiring.
f. The *NEC* is considered to be suitable for mandatory enforcement by government bodies having legal jurisdiction.

Objective 3

Answer should include any three of the following:

a. Installations of electrical conductors and equipment in and on public and private buildings
b. Installations of conductors and equipment that connect to the supply of electricity
c. Installations of outside conductors and equipment
d. Installation of fiber optic cable

Objective 4

Answer should include any three of the following:

a. Installations in ships, watercraft, railway rolling stock, aircraft, and automotive vehicles
b. Installations underground in mines and self-propelled mobile surface mining equipment and its trailing cables
c. Installation of railways used exclusively for operation of rolling stock or exclusively for signaling and communications
d. Installation of communication equipment under control of communication utilities
e. Installations under the exclusive control of electrical utilities

Answers to Written Test

Objective 5

Answer should include any six of the following:

a. Install all types of electrical equipment.
b. Hang electrical fixtures.
c. Install switching and power outlets.
d. Install appliances.
e. Design electrical systems.
f. Troubleshoot and repair defective systems.
g. Practice good work ethic; be dependable and honest.
h. Be courteous to customers and co-workers.
i. Communicate effectively with people.
j. Practice good personal hygiene.
k. Participate in trade organizations.

Objective 6

b, d, e, f

Objective 7

Answer should include the following in any order:

a. Electrician's helper
b. Installer
c. Apprentice
d. Journeyman
e. Master electrician or contractor
f. Maintenance electrician
g. Electrical parts/equipment salesperson
h. Inspector

Objective 8

Answer should include the following in any order:

a. Death
b. Burns
c. Broken bones or bruises
d. Sprains or muscle tear

Objective 9

Answers are:

a. 3
b. 5
c. 1
d. 4
e. 2

Objective 10

Answers are:

a. Obligated
b. Lives
c. License
d. Livelihood

Teacher Supplement 1—Career Listing

Maintenance	Residential (Housing Authority)
Elevator	Installations Maintenance
Communications	Cable Installer Cad 5 Fiber Optics
Security	Commercial–banks Business Residential Medical Alert
Fire	Commercial Industrial
Utilities	Meters (test & repair) Sub-station Power Plant Technician Telephone Installer Sewer Treatment Plant Cable Splicer Rectifier Maintenance Underground Lineman
Government	Military (various) City, State, Federal
Medical	Hospital Maintenance Bio Medicine (i.e. Blood Analyzers, Baby Warmers)
Space Program	Maintenance NASA Electrician Space Station Electrician
Manufacturing	Plant Maintenance Luxury Motor Homes Pre-manufactured Homes
Electronics	Repair Technician Circuit Design IC Chip Manufacturing

Teacher Supplement 1

Instructors	Trade Schools Vo-Techs On-The-Job Junior College Company
Other Industry	Theme Parks Motion Picture Studios Sound Studios Universities Shopping Malls Race Tracks Ball Parks
Inspectors	City State Insurance Real Estate
Miscellaneous	Aircraft (manufacturing, repair, and transportation) Ship/Boat (manufacturing, repair, and transportation) Automotive (manufacturing and repair) Railroads (manufacturing, repair, and operation) Refinery (repair and manufacturing) Union Representatives (various)

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 2–3

Answers to Assignment Sheets 2–9

Written Test 2–11

Answers to Written Test 2–37

Teacher Supplement

1—Respirators 2–43

Transparency Masters

1—Maintain Tools 2–45
2—Safety Tag Color Codes 2–47
3—Classes of Fuel or Fires 2–49
4—Extinguisher Markings 2–51
5—Extinguisher Picture Symbols 2–53
6—How to Lift Safely (1) 2–55
7—How to Lift Safely (2) 2–57
8—Safety Practices for Step Ladders 2–59
9—Safe Ladder Angle 2–61
10—Scaffold Construction 2–63

Student Components

Student Page

Learning Activities Sheet 2–3

Objective Sheet 2–7

Information Sheet 2–9

Student Supplements

1—Complete a Student Safety Pledge Form 2–43
2—Guidelines for Interpreting Material Safety Data Sheet 2–45
3—Using Portable Fire Extinguishers 2–51
4—A Systematic Look At First Aid 2–53

* Focus Assignment

Locate Material Safety Data Sheets 7

Unit Contents

* Assignment Sheets

1—Interpret a Material Safety Data Sheet 9
2—Draw a Layout of Your School Shop and Apply the Safety Color *Code* 15
3—State Portable Fire Extinguisher Types, Symbols, and Operating Instructions 17
4—Identify and Correct Safety Violations 19

* Job Sheets

1—Operate a Fire Extinguisher 21
2—Lift a Heavy Object Properly 23
3—Place and Climb a Ladder Safely 25

* Focus Assignment, Assignment Sheets, and Job Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM 1—Maintain Tools (Objective 3)
TM 2—Safety Tag Color Codes (Objective 17)
TM 3—Classes of Fuel or Fires (Objective 19)
TM 4—Extinguisher Markings (Objective 19)
TM 5—Extinguisher Picture Symbols (Objective 19)
TM 6—How to Lift Safely (Objective 23)
TM 7—How to Lift Safely (Continued)
TM 8—Safety Practices for Step Ladders (Objective 25)
TM 9—Safe Ladder Angle (Objective 25)
TM 10—Scaffold Construction (Objective 26)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have a Red Cross representative demonstrate first-aid techniques and discuss the dangers of bloodborne pathogens.
- Have a local fire marshal or fire extinguisher company representative demonstrate the proper use of fire extinguishers.
- Discuss the fire evacuation plan for the classroom and shop, including evacuation routes and fire exits, as well as after-emergency evacuation routes and procedures for tornado alerts.
- Have a local OSHA inspector talk to the class about OSHA rules and regulations.
- Invite a safety representative from local industry to talk to the class about safety practices and procedures.
- Invite a certified CPR instructor to conduct a class and certify students in administering CPR.
- Obtain a commonly used respirator and demonstrate its use to the class.
- Obtain OSHA Std. 29 CFR 1926.103 or download from www.osha-slc/gov:80/oshstd-data/1926_0103.html prior to discussing objective 10. The standard contains a list of the types of respirators required in specific atmospheres.
- Discuss the Good Samaritan Act and your state's policy on using lifesaving techniques in emergency situations.

- Show students examples of safety signs and tags.
- Obtain OSHA Poster #2203, "Job Safety and Health Protection." Post it in the classroom prior to discussing objective 5.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets.

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Suggested Activities

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *ABC's of Fire Protection.* Belleville, NJ: Walter Kidde & Co., Inc.
- *Safety in Electrical Maintenance.* Rockville, MD: NUS Training Corporation, a Halliburton Company.
- Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- Walker, Susan S. *Introduction to Hospitality and Tourism*, "Unit 3—Basic Workplace Safety and First-Aid Skills." Mid America Vocational Curriculum Consortium Inc., 1993.

Suggested Supplemental Resources

Print Media

- *American Red Cross: Adult CPR.* American National Red Cross

  Note: Contact your local Red Cross chapter to order the most recent edition of this publication.

- *American Red Cross: First Aid and Safety Handbook.* American National Red Cross

  Note: Contact your local Red Cross chapter to order the most recent edition of this publication.

- *Fire Extinguishers, Rating and Fire Test*, Ul 711. Underwriters Laboratories Incorporated, 1995.
- *Material Safety Data Sheet:* Handbook for the Preparation of MSDS Worldwide International Toxic, 1997.
- *OSHA Safety and Health Standards.* Washington, DC: U.S. Department of Labor, Occupational Safety, and Health Administration.

Electronic Media

Videotapes:

- *General Safe Work Practices* (12 Minutes)
  Meets requirements for training exposure to "General Hazards."
- *Fire Extinguisher Training* (8 Minutes)
  Educates employees on the proper and safe use of fire extinguishers and classes of fires.
- *Lifting Safely in Construction* (12 Minutes)
  Demonstrates how the back functions, safest method of lifting, and prevention of back injury.
- *Slips and Falls in Construction* (10 Minutes)
  Highlights individual's responsibility for injury prevention.
- *Ladder Safety in Construction* (9 Minutes)
  Designed for step and straight ladders. Includes rules, 4:1 ratio and unsafe behavior.
- *Scaffold Safety* (8 Minutes)
  Includes safety rules, operating procedures and safe use.
- *Hazard Communications—Right to Know* (10 Minutes)
  Meets OSHA's "Right to Know" requirement.
- *Preventing Back Injuries through Exercise* (9 Minutes)
  Demonstrates basic exercises to "warm up" the back before beginning work.
- *Confined Space Entry* (11 Minutes)
  Meets training requirements for anyone working or entering a confined space. Program reviews the rules, emergency procedures, and more.
- *Bloodborne Pathogens–Construction* (17 Minutes)
  Explains precautions to take when administering first aid on a construction site.
- *Fall Protection* (10 Minutes)
  Covers body harnesses, shock absorbing lanyards, swing effect, rope grabs, and more.
- *"Book 'Em Danno"* (Humorous, 17 Minutes)
  About a 1940's private investigator who reports to work early and walks around the workplace detecting numerous hazards.
- *Heat Stress* (Humorous, 17 Minutes)
  Discusses heat stroke, heat stress, fainting and precautions.
- *Killer Bees, Wasps, and Spiders* (37 Minutes)
  Explains how to avoid the hazards and first-aid treatment in the event of a sting or bite.

Suggested Activities

- *Respirators and How to Use Them* (10 Minutes) Explains the different types of respirators, how they're used, and their capabilities and limitations.

CD Rom

- *First Aid Training*
  Meets OSHA requirements. Topics include: Good samaritan laws, bleeding control, shock, hypothermia, insect bites, burns, asthma, heat stress, strokes, and seizures.

  Note: Order videos and CD ROM from MAVCC, 1500 West Seventh Avenue, Stillwater, OK 74074-4364, e-mail at mavccweb@okvotech.org, visit their web site at www.mavcc.org, or call (800) 654-3988.

Answers to Assignment Sheets

Assignment Sheet 1

Interpret a Material Safety Data Sheet—Gel Grafiti®

1. An engine degreaser
2. Ethanol
3. Opaque white gel
4. 77
5. Carbon dioxide and foam
6. Container may rupture
7. 50 ppm
8. Yes. Chlorinated hydrocarbon has produced cancer in animal studies
9. Inhalation
10. Headaches, dizziness, irritation, burning yes, nausea, asphyxia, and possible chemical pneumonitis if aspirated into lungs
11. The victim should NOT be induced to vomit
12. Heat, sparks, welding arc, open flames
13. Strong oxidizing agents
14. Incinerate or landfill according to state, local, or federal regulations; should not be flushed to sewer
15. Safety glasses, neoprene gloves, and adequate ventilation
16. Wash with soap and water before handling food

Assignment Sheet 2

Draw a Layout of Your School Shop and Apply the Safety Color Code

Students should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 3

State Portable Fire Extinguisher Types, Symbols, and Operating Instructions

a.
   1. f
   2. b
   3. d
   4. a
   5. e
   6. c

b.
   1. c
   2. a
   3. b or e
   4. d
   5. e or b

c.
   1. Pull pin.
   2. Aim nozzle at base of fire.
   3. Squeeze handle.
   4. Sweep nozzle.

Answers to Assignment Sheets

Assignment Sheet 4

Identify and Correct Safety Violations

a. 1. Red warning tag was removed from drill
   2. Did not report stripped wire on drill to instructor
   3. Put drill with other tools
   4. Was going to try to fix drill cord with electrical tape
   5. Afternoon student did not check condition of drill before use
   6. Water on floor was ignored

b. 1. John should have left red warning tag on drill.
   2-3. He should have reported the damaged tool to the instructor and it should have been removed from other tools until fixed.
   4. Repair of tools should be handled by instructor or under the instructor's supervision.
   5. Jim should have checked the condition of the drill prior to plugging it in.
   6. The water spill should have been cleaned up. If water was still running as a result of plumbing work, Jim should have reported condition to the instructor and been assigned another job.

Written Test

Name ____

Date ______________________________ Score______

Objective 1

Match the terms related to general safety below with their correct definitions. Definitions continue on the next page.

1. Accident
2. Cardipulmonary resuscitation
3. Carelessness
4. Combustible
5. Material safety data sheet
6. Safety
7. First-degree burn
8. Third-degree burn
9. Hazard
10. Electrical shock

_____ a. Potential source of danger.

_____ b. Failure to think before one acts; failure to pay attention

_____ c. Burn affecting only the outer skin layers; characterized by redness and pain

_____ d. Suddenly occurring, unintentional event that causes injury or property damage

_____ e. Freedom from danger, risk, or injury

_____ f. Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

_____ g. Burn that destroys all skin layers and underlying tissue; characterized by white, leathery appearance and lack of pain

_____ h. The sudden stimulation of nerves and muscles caused by the discharge of electricity throughout the body when the body contacts an energized electrical circuit

_____ i. Procedure for restoring normal breathing after cardiac arrest

_____ j. Capable of bursting into flames at temperatures above 100°F

Written Test

11. Flammable
12. Hazardous material
13. Hygiene
14. Acquired Immune Deficiency Syndrome (AIDS)
15. Occupational Safety and Health Act
16. First aid
17. Hepatitis
18. Second-degree burn
19. Heel
20. Grounded
21. Anaphylactic shock

_____ k. Capable of being easily ignited and burning quickly at temperatures below 100°F

_____ l. Conditions or practices of cleanliness conducive to health

_____ m. Severe and sometimes fatal reaction to an antigen (as bee venom); characterized by respiratory symptoms, fainting, and itching

_____ n. Life-threatening blood-borne virus that depresses the cells of the immune system

____ o. Any cancer-causing, corrosive, toxic, irritant, sensitizer, or material that has potential for damaging effects on specific body organs

_____ p. Infectious disease marked by inflammation of the liver

_____ q. Burn penetrating beneath the superficial skin layers; characterized by swelling and blisters

_____ r. To apply pressure to the bottom of a straight or extension ladder to prevent it from slipping or sliding sideways while in use

_____ s. Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

_____ t. Federal legislation designed to ensure safe and healthful working conditions for employees

_____ u. Electrical connection to an object that conducts electrical current to the earth

Objective 2

Complete guidelines for dressing safely on the job. Write the correct words in the blanks.

a. Wear ______________________ appropriate for the activity being performed.

b. Wear ______________________ and ______________________ on all construction sites.

c. Always wear ____________________ when working.

d. Remove ____________________ and ____________________ jewelry when working with or near machine tools or rotating equipment.

e. Confine ____________________ before operating rotating equipment.

f. Remove ____________________ and ____________________ when working in the shop.

g. Wear protective ____________________ as appropriate.

h. Wear ____________________ in dusty areas.

i. Wear ____________________ when subjected to continuous loud noise.

j. Wear ____________________ when handling equipment and materials with sharp edges.

Objective 3

Select true general job and shop safety rules by placing an "X" in the blanks next to the true statements.

Awareness and safe conduct

_____ a. Be alert for dangers and hazards

_____ b. Conduct yourself in a safe manner; participate in horseplay only on break periods.

_____ c. Do not work overtime in the shop unless another student is present.

_____ d. Consider the safety of others.

_____ e. Do not distract workers operating a tool or machine.

_____ f. Work with adequate light.

Fire safety

_____ a. Be familiar with the location of building exits and fire-fighting and first-aid equipment.

_____ b. Be aware of the voltage before plugging in a power tool

Tool use, maintenance, and storage safety

_____ a. Use the right tool or equipment for the job, and use it properly.

_____ b. Keep all hand tools in an oil bath until needed.

_____ c. Retain all tool warranties and purchase orders.

_____ d. Operate a hazardous machine only after receiving instruction on how to operate the machine safely in all working conditions.

_____ e. Make sure that all guards and barriers are in place and adjusted properly before using a machine tool.

_____ f. Use correct, properly fitting drill bit for nuts, bolts, and objects to be turned or held.

_____ g. Keep work areas clean and free of debris and other hazards.

_____ h. Store tools, materials, and supplies safely in cabinets, on shelves, or other suitable areas.

_____ i. Keep sufficient brooms, brushes, and other housekeeping equipment readily available.

_____ j. Clean chips from a machine with a rag on your bare hands, not with a brush.

_____ k. Wear hand protection when using grinders and buffers.

Hazardous materials safety

_____ a. Use a solvent only after determining its properties, the kind of work it has to do, and how to use it.

_____ b. Use and store potentially hazardous materials and products strictly according to warranty instructions and cautions.

_____ c. Clean up any spilled liquids immediately.

_____ d. Store oily rags or oily waste in self-closing or spring-lid plastic containers.

Electrical safety

_____ a. Check all equipment before energizing or activating.

_____ b. Disconnect the power from energized tools, and tag or lockout machine tools, before performing any maintenance task such as oiling or cleaning.

_____ c. Do not run over electrical cords with dollies or carts.

_____ d. Tape down electrical cords that cross traffic lanes.

_____ e. Turn off the power before leaving a power tool or machine.

Objective 4

List shop conditions that should be reported.

a.____

b.____

c.____

Objective 5

Select words to complete facts about OSHA's role in workplace health and safety. Write the correct numbers in the blanks at left.

_____ a. OSHA became federal law on April 28, _____.

1. 1961
2. 1971
3. 1984
4. 1974

_____ b. OSHA operates under the U.S. Department of _____.

1. Health
2. Commerce
3. Labor
4. Human Services

_____ c. OSHA sets _____ major requirements for employers.

1. two
2. three
3. four
4. five

_____ d. OSHA requires each employer to furnish a place of employment that is free from recognized hazards that are causing or are likely to cause _____.

1. illness
2. allergic reactions
3. communicable diseases
4. death or serious injury

_____ e. OSHA requires that employers _____ the occupational safety and health standards contained within the OSHA regulations.

1. list
2. comply with
3. legalize
4. provide each employee with

_____ f. OSHA requires employees to comply with occupational safety and health standards and all rules, regulations, and orders pursuant to OSHA regulations that are applicable to the employee's own _____.

1. age
2. job description
3. actions and conduct
4. health and hygiene

_____ g. OSHA requires that employers _____ occupational injuries and illnesses of their employees.

1. keep records of
2. prevent all
3. provide insurance for all
4. list with the National Center for Disease Control all

_____ h. OSHA requires that employers keep _____ all hazardous substances used by employees.

1. in a locked cupboard
2. to a minimum
3. contact reports on
4. material safety data sheets on

_____ i. OSHA often sets only _____ standards and requirements.

1. the strictest maximum
2. general
3. minimum
4. suggested

_____ j. OSHA provides for federal OSHA officers who visit facilities and _____.

1. arrest employers who are in noncompliance
2. fire employers/employees who are in noncompliance
3. levy penalties for noncompliance
4. train employees who are in noncompliance

Objective 6

Match the terms related to fall protection systems below with their correct definitions. Write the correct numbers in the blanks.

1. Anchorage
2. Body Belt
3. Body Harness
4. Connector
5. Guardrail System
6. Hole
7. Lanyard
8. Lifeline
9. Lower Levels
10. Personal Fall Arrest System
11. Safety Net
12. Walking/Working Level

_____ a. A barrier erected to prevent employees from falling to lower levels

_____ b. Erected under a walking/working level when guardrail systems or personal fall arrest systems are not feasible

_____ c. Straps which may be secured about the employee in a manner that will distribute the fall arrest forces over at least the thighs, pelvis, waist, chest and shoulders with means for attaching it to other components of a personal fall arrest system

_____ d. A component consisting of a flexible line for connection to an anchorage at one end to hang vertically, or at both ends to hang horizontally

_____ e. A gap or void 2 inches of more in dimension, in a floor, roof, or other walking/working surface

_____ f. A strap with means both for securing it about the waist and for attaching it to a lanyard, lifeline, or deceleration device

_____ g. A flexible line of rope or strap which generally has a connector at each end for connecting the body harness to a deceleration device, lifeline, or anchorage

_____ h. A device which is used to couple (connect) parts of the personal fall arrest system

_____ i. Those areas or surfaces to which an employee can fall. Such areas or surfaces include, but are not limited to, ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures, or any portion of these

_____ j. A secure point of attachment for lifelines or lanyards

_____ k. A system used to arrest an employee in a fall from a working level. It consists of an anchorage, connectors, a body harnes, and may include a lanyard, deceleration device, lifeline, or suitable combinations of these

_____ l. Any surface, whether horizontal or vertical, on which an employee walks or works, including, but not limited to, floors, roofs, ramps, bridges, scaffolds, and runways, but not including ladders, vehicles, or trailers, on which employees must be located in order to perform their job duties

Written Test

Objective 7

Select true statements about fall protection systems by placing an "X" in the blanks next to the true statements.

Guardrail Systems

_____ a. Used primarily on scaffolding, around holes, and on ramps and runways

_____ b. Not required when a safety monitor is nearby

_____ c. Top edge height of a guardrail shall be a minimum of 39 inches

_____ d. Only required when the walking/working surface is 8 feet or more from the ground

Safety Nets

_____ a. Shall be installed as close as practical under the walking/working surface on which employees are working, but in no case more than 20 feet below that level

_____ b. Shall be inspected at least once a week for wear, damage and other deterioration

_____ c. Erected under walking/working level when guardrail systems or personal fall arrest systems are not feasible

_____ d. Materials, scrap pieces, equipment, and tools which have fallen into the safety net shall be removed as soon as practical from the net or at least once a week

Personal Fall Arrest System

_____ a. Consists of an anchorage, connectors, a body harness, and may include a lanyard, deceleration device, lifeline, or suitable combinations of both

_____ b. Attachment point of the body harness shall be located in the center of the wearer's back under shoulder level, and in no instance should it be above the wearer's head

_____ c. When used for attachment of fall arrest equipment, they shall be independent of any anchorage being used to support or suspend platforms and capable of supporting at least 2,000 pounds per employee attached

_____ d. Shall be rigged so that an employee can't free fall more than 6 feet or contact any lower level

_____ e. May be attached to guardrail systems but not hoists

_____ f. Shall be inspected prior to each use for wear, damage and other deterioration, and defective components shall be removed from service

Written Test

Objective 8

Match the terms related to confined space entry below with their correct characteristics. Some terms may have multiple characteristics. Write the correct numbers in the blanks.

1. Confined Space
2. Non-Permit Confined Space
3. Permit Required Confined Space
4. Permit Required Confined Space Program

_____ a. Contains a material for engulfing an entrant

_____ b. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section

_____ c. Large enough or so configured that an employee can bodily enter and perform assigned work

_____ d. Controls and protects employees from permit space hazards and regulates employee entry into permit spaces

_____ e. Is not designed for continuous employee occupancy

_____ f. Contains a recognized serious safety or health hazard

_____ g. Has limited or restricted means for entry or exit

_____ h. A confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm

_____ i. Contains or has potential to contain a hazardous atmosphere

Objective 9

List 5 employer responsibilities associated with confined space entry.

a.____

b.____

c.____

d.____

e.____

List 6 employee responsibilities associated with confined space entry.

a.____

b.____

c.____

d.____

e.____

f.____

Objective 10

List 7 environmental contaminants that would require you to use a respirator.

a.____

b.____

c.____

d.____

e.____

f.____

g.____

Objective 11

Select true statements about hazardous cleaners and lubricants by placing an "X" in the blanks next to the true statements.

_____ a. Acetone is an acid that cleans solder connections.

_____ b. Kerosene may be used as a machine cutting fluid.

_____ c. Mineral spirits is a petroleum solvent that acts as a thinner for rubber, oil, and alkyd enamels.

_____ d. Bright dip is an acid mixture containing sulfuric, hydrochloric, and nitric acids.

_____ e. Lacquer thinner may be used as a coolant.

_____ f. Isophorone is used for oil and grease wash-up.

_____ g. Ethyl alcohol is not petroleum based.

_____ h. Hydrochloric acid is diluted acid that removes mill scale from steel.

_____ i. Cyclohexanone is vinyl solvent and cement thinner.

Objective 12

Complete statements concerning the storage of hazardous materials by circling the word(s) that best completes each statement.

a. Select an area that meets local, state, and national (**opinions, codes**).

b. Store materials in (**metal cabinets, plastic baskets**).

c. Keep storage area (**locked, open**).

d. Store in open area (**near, away from**) open flame or excessive heat.

e. Always read (**text, labels**) for instructions on proper storage use.

Objective 13

Distinguish between two common hazardous materials found at the job site. Write "P" before the correct description of PCB.

_____ a. Used on ceilings, boilers, and electrical wiring as a heat retardant; highly suspected of causing cancer.

_____ b. Fire resistant, helps improve the coolant and dielectric properties of oil; can be harmful if absorbed into the skin; suspected of being cancer-causing.

Objective 14

Select words to complete facts about the purposes of material safety data sheets (MSDS). Write the correct numbers in the blanks at left.

_____ a. To inform _____ of the material's physical properties or fast-acting health effects that make it dangerous to handle.

1. OSHA
2. the management
3. the user
4. the health department

_____ b. To tell the user the level of _____ needed.

1. protective gear
2. medical care
3. hygiene
4. management

_____ c. To tell the user the _____ necessary if exposed to the product or its hazards.

1. preplanning
2. OSHA regulations
3. legal actions
4. first-aid treatment

_____ d. To tell the management and the user the _____ needed for safely handling spills, fires, and day-to-day operations.

1. legal actions
2. preplanning
3. equipment and materials
4. personnel resources

_____ e. To tell the user how to _____ accidents.

1. report
2. respond to
3. prevent
4. record

Objective 15

Describe ways hazardous materials can enter the body.

a. Ingestion— ____

____

b. Absorption—____

____

c. Inhalation— ____

____

Objective 16

Match the colors of the safety color code with their uses. Write the correct number in the blanks.

1. Federal safety green
2. Federal safety white and black
3. Federal safety orange
4. Federal safety purple
5. Federal safety red
6. Federal safety yellow

_____ a. Designates caution and for marking physical hazards, waste containers for explosive or combustible materials; caution against starting, using, or moving equipment under repair; identification of the starting point or power source of machinery

_____ b. Identifies fire protection equipment and apparatus, portable container of flammable liquids, emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

_____ c. Designates safety and the location of first aid equipment

_____ d. Designates dangerous parts of machines, safety starter buttons, parts of equipment that may produce electrical shock, and the exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

_____ e. Designates traffic flow; housekeeping zones

_____ f. Identifies fire protection equipment and apparatus, portable

Objective 17

Match illustrated safety tags with their color coding. Write the correct number in the blanks.

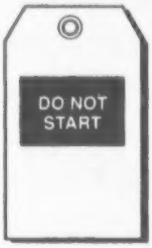
_____ a. White tag, white letters on red square

_____ b. White tag, white letters in red oval, on black square

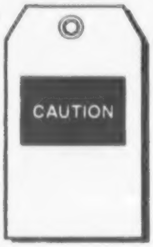
_____ c. Yellow tag, yellow letters on black background

_____ d. Blue tag, white letters on black background

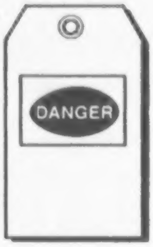
1.



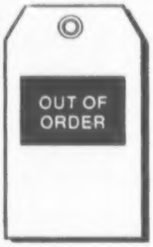
2.



3.



4.



Objective 18

List the components of the fire triangle.

a. ____________________

b. ____________________

c. ____________________

Objective 19

Match types of fires with their classifications. Write the correct numbers in the blanks.

1. Class A	3. Class C
2. Class B	4. Class D

_____ a. Fires that occur in electrical and electronic equipment

_____ b. Fires that occur in flammable liquids

_____ c. Fires that occur in ordinary combustible materials

_____ d. Fires that occur in combustible metals

Written Test

Objective 20

Match types of fires extinguishers with their uses. Write the correct numbers in the blanks.

1. Carbon dioxide
2. Halon
3. Pump tank
4. Dry chemical
5. Foam

_____ a. Place foot on foot pump and direct stream at base of fire; use on Class A fires only.

_____ b. Direct discharge as close to fire as possible, first at the edge of flames, then gradually forward and upward; use for Class B or Class C fires.

_____ c. Instead of spraying stream into the burning liquid, allow substance to fall lightly on the fire; use for Class A or Class B fires.

_____ d. Direct at the base of the flames and follow up by directing at remaining material that is burning; use for Class B or Class C fires.

_____ e. Stand back 10 feet, hold upright and direct at the base of fire, sweeping from side to side; use for Class C fires.

Objective 21

Complete fire extinguisher general operating instructions that follow the letters P-A-S-S

a. P ______________________________

b. A ______________________________

c. S ______________________________

d. S ______________________________

Objective 22

Match causes of back injuries with their contributing factors. Write the correct numbers in the blanks.

1. Improper storage
2. Weight
3. Obstructions
4. Improper reaching
5. Size
6. Shape
7. Improper position

_____ a. Injury usually results from overestimating your physical abilities and trying to lift more weight than you can handle.

_____ b. Injury usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

_____ c. Injury usually results from moving an object that may be within your weight capacity, but has a cylindrical or other odd shape that makes lifting difficult.

_____ d. Injury usually results from stacking materials so high that vision is limited and obstructions in the pathways cannot be seen.

_____ e. Injury usually results from twisting or turning to an awkward position when lifting.

_____ f. Injury usually results in strain caused by not storing heavy objects at least 12 inches off the floor.

_____ g. Injury usually results from carelessly using chairs or boxes instead of safely using a ladder, or by positioning elevating object too far from work.

Objective 23

Select words to complete the guidelines for lifting and moving items safely. Write the correct numbers in the blanks at left.

Before lifting

_____ a. Inspect the item to be lifted for _____, and grease or other slippery surfaces.

1. wrapping, handholds
2. jagged edges, splinters
3. size, weight
4. obstacles, wrapping

_____ b. Wear _____ for protection, and make sure they fit correctly.

1. steel-toed shoes
2. safety goggles
3. ankle supports
4. gloves

_____ c. Wear _____ support.

1. abdominal
2. lower-back
3. neck
4. shoulder

_____ d. Plan your _____ before you lift.

1. strategy
2. tactics
3. route
4. position

_____ e. Clear any _____ from your path.

1. obstacles
2. guests
3. employees
4. floor coverings

_____ f. Assess the _____ of the load.

1. area
2. circumference
3. square footage
4. weight

_____ g. _____ to lift heavy loads.

1. Use your back
2. Get help
3. Call a professional
4. Use a pry bar

_____ h. Use a _____ to move very heavy, large, or awkward loads that cannot (or should not) be lifted by two people.

1. ramp
2. dolly
3. laundry cart
4. bus cart

Lifting

_____ i. Place your _____ as close to the load as possible.

1. head
2. shoulders
3. hip
4. feet

_____ j. Bend your knees, keeping your _____ straight and your chin tucked in.

1. leg muscles
2. arms and shoulders
3. back and neck
4. feet

_____ k. Grasp the load _____ with your fingers and hands.

1. loosely
2. at the top
3. at the bottom
4. firmly

_____ l. Draw your _____ in close to your body.

1. arms
2. knees
3. feet
4. buttocks

_____ m. Stand slowly and lift smoothly, using your _____.

1. legs
2. shoulders
3. back
4. knees

Carrying

_____ n. Hold the item _____.

1. at least 1 foot from waist
2. at knee level
3. at shoulder level
4. close to your body

_____ o. Do not allow the load to _____.

1. touch your chest
2. rest on your shoulder
3. block your vision
4. shift toward your body

_____ p. Do not _____ or twist your body to change direction.

1. set the load down
2. turn your head
3. change your grip
4. adjust your footing

_____ q. Learn the _____.

1. hip carry
2. shoulder carry
3. knee support carry
4. head carry

Setting the load down

_____ r. Bend your _____.

1. arms
2. knees
3. back
4. head

_____ s. Keep your _____ straight and aligned.

1. back and neck
2. knees and legs
3. arms and elbows
4. chin and head

_____ t. Place the load carefully on the floor or shelf, taking care not to set it _____.

1. on your fingers or feet
2. on an even surface
3. toward the back of the receiving surface
4. squarely on the receiving surface

_____ u. Be sure the load is _____.

1. properly wrapped
2. closed
3. tied properly
4. secure

Objective 24

List five guidelines for preventing slips, trips, and falls.

a. ____

b. ____

c. ____

d. ____

e. ____

Objective 25

Select words to complete rules for using ladders safely. Write the correct numbers in the blanks at left.

_____ a. Make sure that the ladder has non-skid safety _____.

1. hooks
2. shoes
3. rungs
4. beams

_____ b. Inspect the ladder before use for worn safety shoes, broken or loose _____ or other defects.

1. paint
2. screws
3. rungs/steps
4. truss blocks

_____ c. Inspect the ladder rungs/steps and siderails for _____ before you climb.

1. chipped or worn paint
2. oil or other slippery materials
3. levelness and construction
4. non-skid surfaces and dirt

_____ d. Be sure that ladders—particularly _____ ladders—are clear of electrical hazards.

1. metal
2. wood
3. fiberglass
4. composition

_____ e. Locate the ladder away from doors or other openings that are not _____.

1. open
2. closed
3. outswinging
4. blocked or guarded

_____ f. Place the ladder feet on a _____, non-skid surface.

1. perpendicular
2. level
3. smooth
4. vertical

_____ g. Place the ladder at a safe angle to the work: at least _____ from the wall for each _____ of height.

1. 6 inches; 1 foot
2. 2 feet; 10 feet
3. 1 foot; 4 feet
4. 8 inches; 3 feet

_____ h. Use _____ to secure sections of extension ladders.

1. rung locks
2. a screwdriver
3. properly knotted rope
4. vise-grip pliers

_____ i. Place the top of extension and straight ladders at least _____ rungs above the work.

1. one
2. two
3. three
4. four

_____ j. Get a helper to _____ straight or extension ladders.

1. toe
2. foot
3. heel
4. boot

_____ k. _____ the ladder when climbing up and down.

1. Face
2. Keep your back to
3. Skip rungs of
4. Hug

_____ l. Never stand on the _____ rung/step.

1. lowest
2. top
3. center of the
4. edges of the

_____ m. Do not _____ while on the ladder; descend the ladder and reposition it instead.

1. overextend your reach
2. reach above your head
3. work to the right
4. work to the left

_____ n. Allow only _____ on the ladder at a time.

1. four persons
2. three persons
3. two persons
4. one person

_____ o. Do not use ladders for_____.

1. cleaning windows
2. makeshift scaffolds
3. emergency exits
4. cleaning electrical fixtures

_____ p. Store ladders _____ when not in use.

1. securely
2. off the ground
3. in vertical position
4. on their sides

Objective 26

Select from a list of safety guidelines for using scaffolds by placing an "X" in the blanks next to the true statements.

_____ a. Never ride a scaffold when it is being moved.

_____ b. Scaffolding is easy to assemble and can be done alone.

_____ c. Secure scaffold wheel locks before climbing.

_____ d. Always use the proper planks when assembling.

_____ e. Never climb a scaffold unless at least three scaffold legs are on the ground.

Objective 27

Select from a list of safety guidelines for using power lifts by placing an "X" in the blanks next to the true statements.

_____ a. Operate lifts on uneven surfaces.

_____ b. Never lift over the weight-rated capacity of the lift.

_____ c. Always check for objects in the pathway.

_____ d. Never put arms or legs in lift.

_____ e. When moving lift, assume workers will get out of the way.

Written Test

Objective 28

List in order, the general steps for handling any emergency situation.

a. Step 1: ______________________________

b. Step 2: ______________________________

c. Step 3: ______________________________

d. Step 4: ______________________________

Objective 29

Complete statements concerning general guidelines for first aid emergencies by writing the word(s) that best completes each statement.

a. Before administering first aid, always have a ____________ for what you do.

b. ____________ the injured person that everything possible is being done.

c. Make ____________ ____________ about the accident including name of victim, time, place, cause or nature of the accident, and any first aid that was administered.

d. Do not ____________ the victim's family because this is the responsibility of the school, the job site supervisor, or the medical facility.

c. Report all accidents and injuries to your instructor or job site supervisor, no matter how ____________ they may seem.

Objective 30

Describe basic first-aid procedures for various emergency situations.

Bleeding

a. Severe: ______________________________

____

b. Minor: ______________________________

____

Burns

a. Third-degree: ______________________________

____

b. Second-degree: ______________________________

____

c. First-degree: ________________________________

____

d. Chemical: ________________________________

____

e. Electrical: ________________________________

____

Traumatic shock

a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

Falls

a. Head injury: ________________________________

____

b. Less severe falls: ________________________________

____

Choking

a. ________________________________

____

b. ________________________________

____

Heart attack

a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

Electrical accident

a. ______________________

b. ______________________

c. ______________________

d. ______________________

Heat exhaustion

a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

Heat stroke

a. ______________________

b. ______________________

c. ______________________

d. ______________________

Insect stings

a. Ordinary reaction: ______________________

____

____

b. Allergic reaction: ______________________

____

____

Seizure

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	9	h.	10	o.	12
b.	3	i.	2	p.	17
c.	7	j.	4	q.	18
d.	1	k.	11	r.	19
e.	6	l.	13	s.	16
f.	5	m.	21	t.	15
g.	8	n.	14	u.	20

Objective 2

a. Clothing
b. Hard hats, safety shoes
c. Safety glasses
d. Ties, dangling jewelry
e. Long hair
f. Rings, other jewelry
g. Protective clothing
h. Dust masks
i. Hearing protection
j. Gloves

Objective 3

Awareness and safe conduct—a, d, e, f
Fire safety—a
Tool use, maintenance, and storage safety—a, d, e, g, h, i
Hazardous materials safety—a, c
Electrical safety—a, b, c, e

Objective 4

a. Equipment defects
b. Any condition than can lead to an accident
c. All accidents and injuries, no matter how minor

Objective 5

a.	2	f.	3
b.	3	g.	1
c.	1	h.	4
d.	4	i.	3
e.	2	j.	3

Objective 6

a.	5	g.	7
b.	11	h.	4
c.	3	i.	9
d.	8	j.	1
e.	6	k.	10
f.	2	l.	12

Answers to Written Test

Objective 7

Guardrail Systems—a, c
Safety Nets—b, c
Personal Fall Arrest System—a,d,f

Objective 8

a. 3
b. 3
c. 1
d. 4
e. 1
f. 3
g. 1
h. 2
i. 3

Objective 9

Five employer responsibilities

a. Determine whether confined spaces require a permit to enter
b. Inform exposed employees, by posting danger signs or by any other equally effective means, of the existence and location of, and the danger posed by the permit spaces
c. Develop and implement a written permit space program
d. Provide all equipment necessary to allow the employee to complete the job safely
e. Provide training so that all employees who may enter confined spaces acquire the understanding, knowledge, and skills necessary for the safe performance of duties

Six employee responsibilities

a. Never enter any confined space without first finding out whether it requires a permit.
b. If entry does require a permit, thoroughly read all instructions before entering and ensure the permit is posted at the entry portal so you can confirm that pre-entry preparations have been completed.
c. Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure.
d. Never enter a permit-required confined space without an attendant present, and always maintain constant communication with the attendant.
e. Alert the attendant whenever you detect a prohibited condition.
f. Properly use provided equipment.

Objective 10

Answers may be given in any order.

a. harmful dusts
b. fogs
c. fumes
d. mists
e. gases
f. smokes
g. sprays
h. vapors

Answers to Written Test

Objective 11	b, c, d, h, i
Objective 12	a. Codes b. Metal cabinets c. Locked d. Away from e. Labels
Objective 13	a
Objective 14	a. 3 b. 1 c. 4 d. 2 e. 2
Objective 15	a. By mouth b. Through the skin c. By breathing in gases, vapors, fumes, and other forms of a material
Objective 16	a. 6 b. 5 c. 1 d. 3 e. 2 f. 4
Objective 17	a. 1 b. 3 c. 2 d. 4
Objective 18	a. Fuel b. Heat c. Oxygen
Objective 19	a. 3 b. 2 c. 1 d. 4
Objective 20	a. 3 b. 1 c. 5 d. 4 e. 2
Objective 21	a. Pull pin. b. Aim nozzle toward fire. c. Squeeze handle. d. Sweep nozzle back and forth at base of flames.

Answers to Written Test

Objective 22

a. 2
b. 5
c. 6
d. 3
d. 7
e. 1
g. 4

Objective 23

a. 2
b. 4
c. 2
d. 3
e. 1
f. 4
g. 2
h. 2
i. 4
j. 3
k. 4
l. 1
m. 1
n. 4
o. 3
p. 3
q. 2
r. 2
s. 1
t. 1
u. 4

Objective 24

Answer should include any five of the following:

a. Wipe up spills immediately.
b. Post warning signs when floors are wet.
c. Use handrails on stairs.
d. Report any tripping hazard.
e. Do not leave equipment, materials, or other obstacles in hallways, on stairs or landings, before doors and exits, or in any other area where people may trip over them.
f. Do not stretch extension cords across traffic areas.
g. Use a ladder instead of a chair or box to reach high objects or areas.

Objective 25

a. 2
b. 3
c. 2
d. 1
e. 4
f. 2
g. 3
h. 1
i. 3
j. 3
k. 1
l. 2
m. 1
n. 4
o. 2
p. 1

Objective 26

a, c, d

Objective 27

b, c, d

Objective 28

a. Determine the type of emergency.
b. Notify the appropriate medical or law-enforcement authority.
c. Notify the management.
d. Provide basic first aid, or seek assistance from other employees until proper authorities arrive.

Objective 29

a. Reason
b. Reassure
c. Accurate notes
d. Notify
e. Minor

Objective 30

Bleeding

a. Apply pressure dressing or manual pressure to wound.
b. Apply antiseptic solution and dress with sterile bandages.

Burns

a. Cool with a damp compress and then cover with a dry, sterile dressing; cover victim with a blanket to prevent loss of body heat.
b. Cool with a damp compress—taking care not to break blisters—and then cover with a dry, sterile dressing to prevent infection.
c. Hold under cold water; apply dry, sterile dressing.
d. Flush skin thoroughly with clean water.
e. Locate both entrance and exit burns, and treat as a third-degree burn.

Eye injury

a. Minor: Have the victim close his or her eyes; put a piece of moist cotton over the closed lid; place a bandage over the cotton; get the victim to a doctor as soon as possible.
b. More severe injury—Apply a sterile dressing, bandage *loosely*, and get medical help immediately.
c. Chemical injury—Flush eyes immediately at an eye-flushing station, or use a bottled, portable flushing solution; then seek immediate medical assistance.

Traumatic shock

a. Recognize the signs and symptoms of traumatic shock.
b. Lay victim down
c. Elevate victim's legs slightly.
d. Cover to prevent loss of body heat.

Falls

a. Lay victim flat; control bleeding.
b. Check for injury and provide first aid as appropriate; do not move victim—or allow victim to move—if a neck or back injury is suspected.

Choking

a. Recognize the signs and symptoms of choking.
b. Perform the Heimlich maneuver.

Heart attack

a. Recognize the signs and symptoms of heart attack.
b. Help victim to a less painful position.
c. Loosen victim's clothing around the neck and midriff.
d. Apply CPR if required and you are qualified.

Electrical accident

a. Do **not** provide any medical assistance until all electrical current has been shut off.
b. Administer CPR if necessary.
c. Treat for traumatic shock.
d. Treat for electrical burn.

Heat exhaustion

a. Recognize the signs and symptoms of heat exhaustion.
b. Immediately move victim to a cool place.
c. Lay victim flat.
d. Elevate victim's feet slightly.
e. Remove as much of victim's clothes as possible.
f. Sponge victim with cool water.

Heat stroke

a. Recognize the signs and symptoms of heat stroke.
b. Move victim to a cool location.
c. Cool victim as quickly as possible.
d. Rub ice on victim's extremities.

Insect stings

a. Scrape stinger sideways away from wound; wash wound with soap and water; apply ice to reduce swelling.
b. If possible, immediately transport victim to a hospital or doctor's office; if transportation is not immediately available, lay victim down or help victim to a position in which he or she can breathe more easily; elevate victim's legs if possible; while waiting for emergency help, remove stinger and perform first-aid actions for an ordinary sting.

Seizure

a. Help victim lie on the ground or floor if possible.
b. Do not try to restrain victim.
c. Clear area of hard or dangerous objects to protect victim from self-injury.
d. Remove victim's eyeglasses, if applicable, and loosen clothing in the head and neck area.
e. Turn victim to the side to allow saliva to drain from the mouth.
f. Transport victim to a hospital or doctor's office after the seizure has passed.

Teacher Supplement 1—Respirators

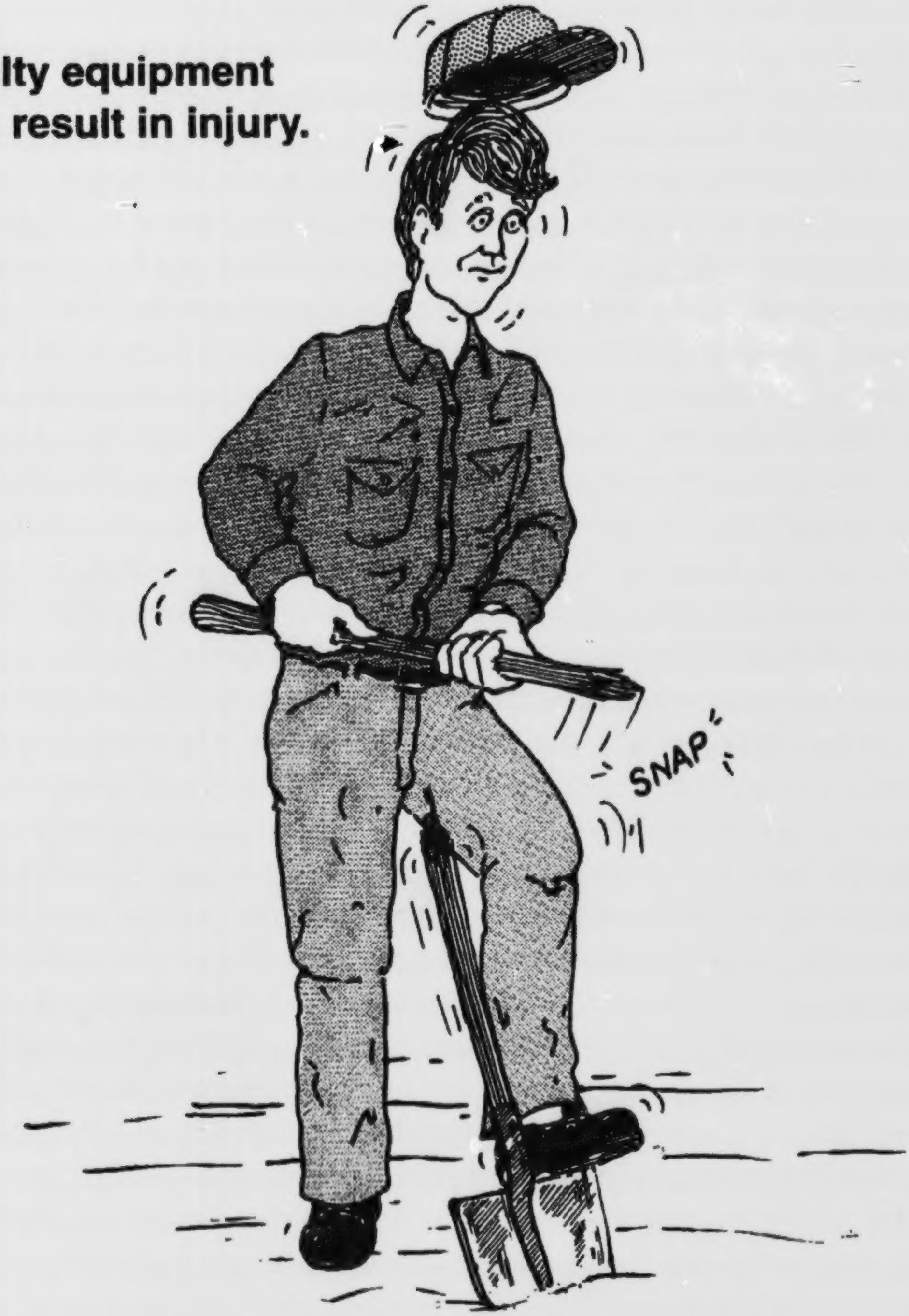
Note: Before considering respirator use, the primary objective shall be to control occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors. This will be accomplished by engineering measures (for example,enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). If this isn't possible, or while the procedures are being completed, appropriate respirators shall be used.

1. Persons should not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (for instance, annually).
2. Respirator selection is based on:
   a. The chemical and physical properties of the contaminant, as well as how toxic (deadly) it is, and how much there is of it.
   b. What the hazard is, the work requirements and condition, and the limitation and characteristics of the available respirators
3. Respirators shall be approved by the Mine Safety and Health Administration and the National Institute for Occupational Safety, or acceptable to the U.S. Department of Labor for the specific contaminant to which the employee is exposed.
4. The employer shall provide respirators when necessary to protect the health of an employee, and be responsible for the establishment and maintenance of a respiratory protective program that includes:
   a. Selecting the proper respirator
   b. Training the employee in the proper use of the selected respirator
   c. Providing a storage area
   d. Establishing a periodic inspection and cleaning program
   e. Establishing written procedures covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or emergencies
5. OSHA Standard 29 CFR–1926.103 lists the types of respirators required for protection in dangerous atmospheres.

Caution: In areas where the wearer, with failure of the respirator, could be overcome by a toxic or oxygen-deficient atmosphere, at least one additional man shall be present. Communications (visual, voice, or signal line) shall be maintained between both or all individuals present. Rescue equipment must be available.

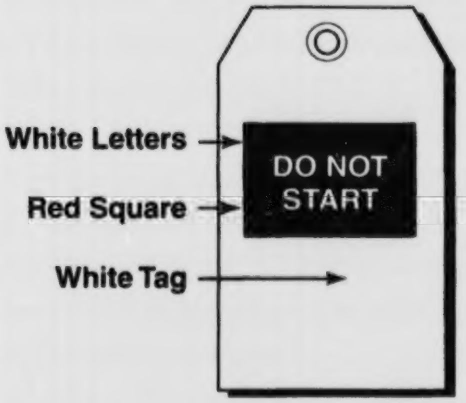
Maintain Tools

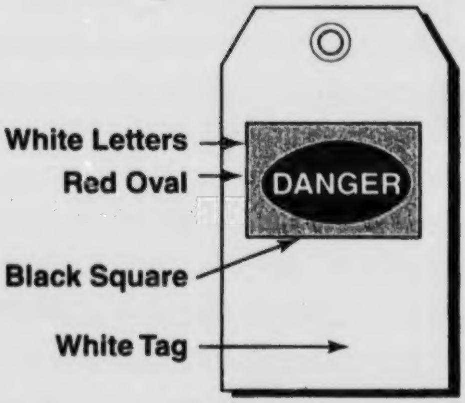
Faulty equipment can result in injury.

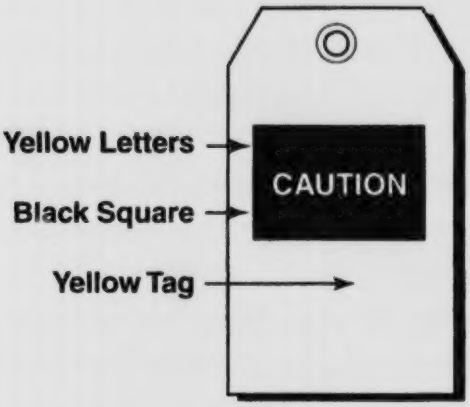


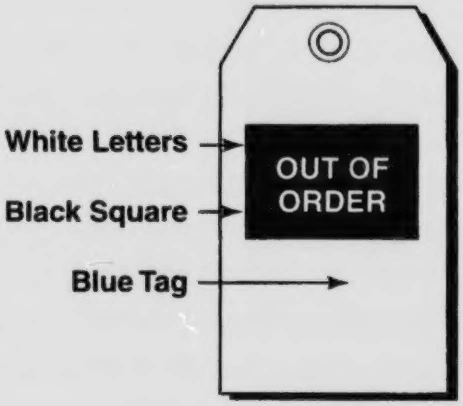
TM 1

Safety Tag Color Codes


White Letters
DO NOT START
Red Square
White Tag


White Letters
Red Oval
DANGER
Black Square
White Tag


Yellow Letters
CAUTION
Black Square
Yellow Tag


White Letters
OUT OF ORDER
Black Square
Blue Tag

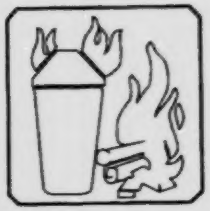
Classes of Fuel or Fires

(Green)

A

Class A

- Ordinary combustibles

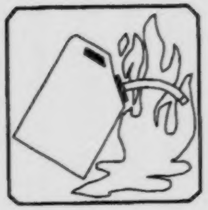


(Red)

B

Class B

- Flammable liquids and gases

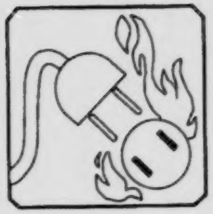


(Blue)

C

Class C

- Live electrical equipment

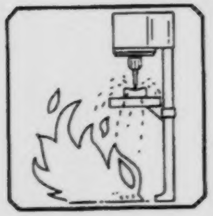


(Yellow)

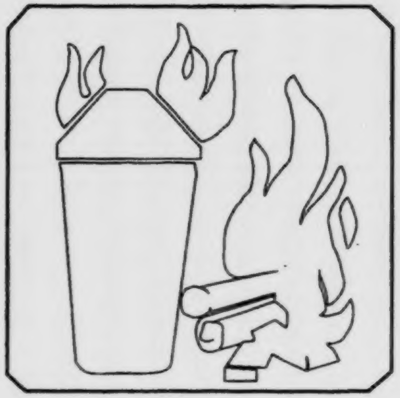
D

Class D

- Combustilbe metals



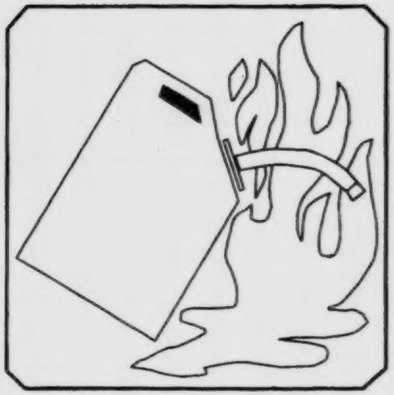
Extinguisher Markings



Ordinary

A

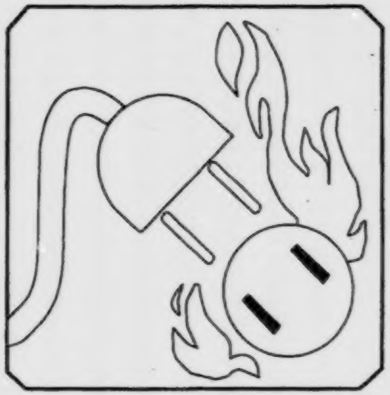
Combustibles
(Green)



Flammable

B

Liquids
(Red)

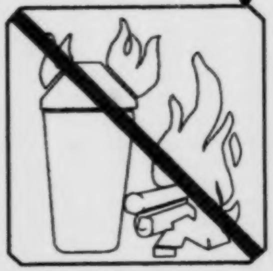
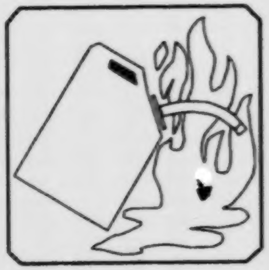
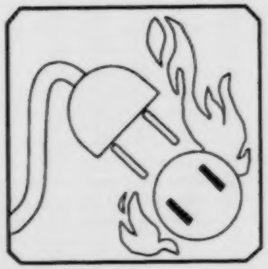
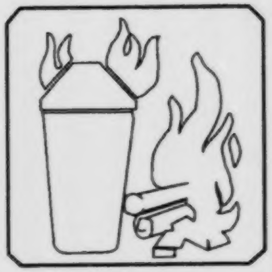
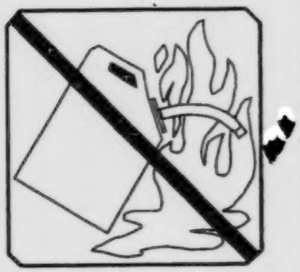
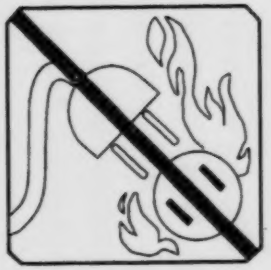
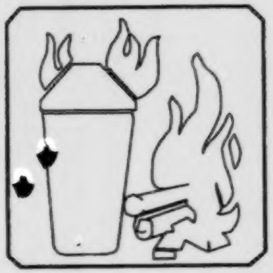
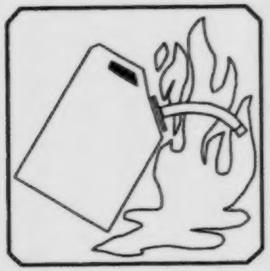
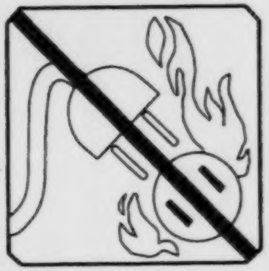


Electrical

C

Equipment
(Blue)

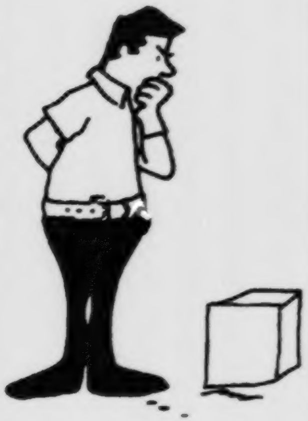
Extinguisher Picture Symbols

			Picture symbols for extinguishers suitable for Class B and C fires, but **not** for Class A fires.
			Picture symbols for extinguishers suitable for Class A fires, but **not** for Class B and C fires.
			Picture symbols for extinguishers suitable for Class A and B fires, but **not** for Class C fires.

How to Lift Safely

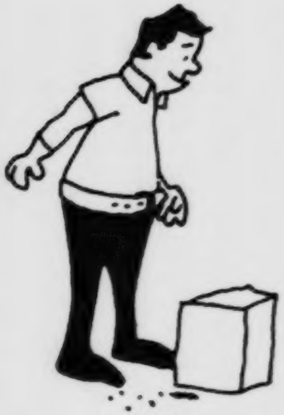
1

Approach the load and size it up as to weight, size, and shape. Consider your physical ability to handle the load.



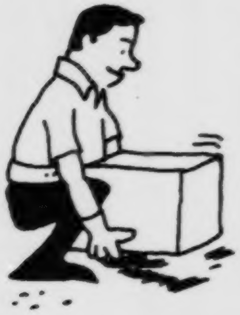
2

Place feet close to the object to be lifted and 8 to 12 inches apart for good balance.



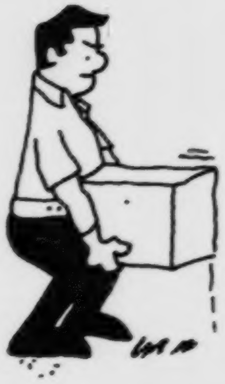
3

Bend the knees to the degree that is comfortable and get a good handhold. Then using both leg and back muscles. . .



4

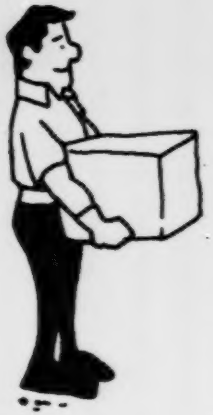
Lift the load straight up smoothly and evenly. Push with your legs, and keep the load close to your body.



How to Lift Safely (Continued)

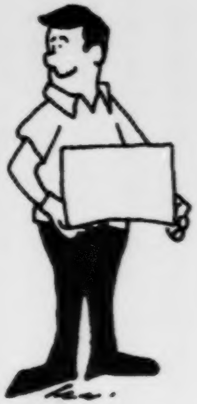
5

Lift the object into carrying position, making no turning or twisting movements until the lift is completed.



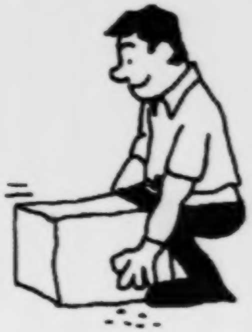
6

Turn your body with changes of foot position after looking over your path of travel, making sure it is clear.

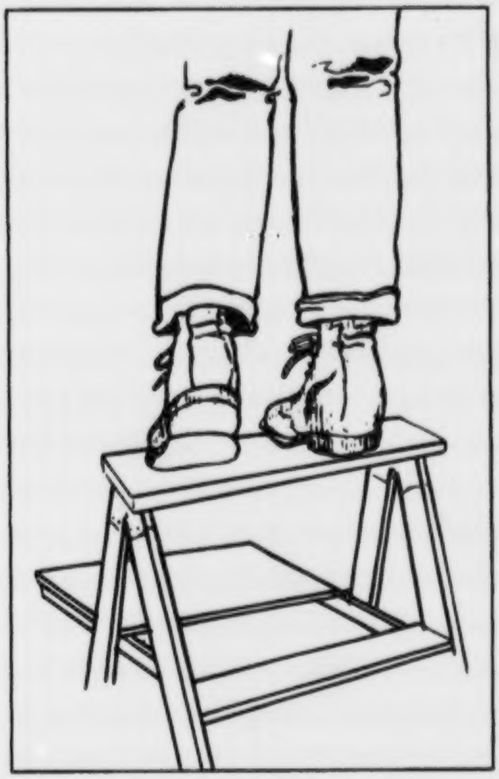


7

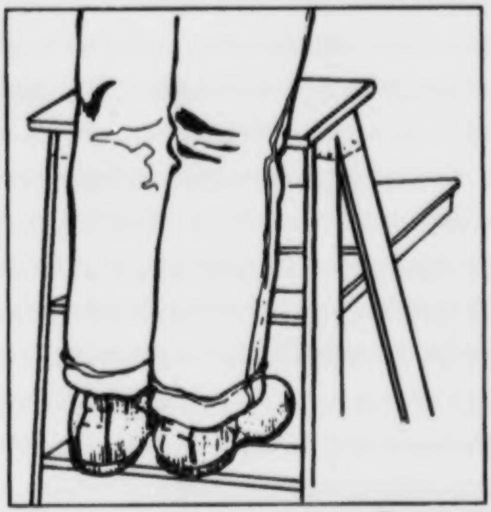
Setting the load down is just as important as picking it up. Using leg and back muscles, comfortably lower load by bending your knees. When load is securely positioned, release your grip.



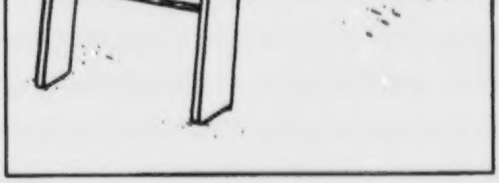
Safety Practices for Step Ladders



Incorrect



Correct

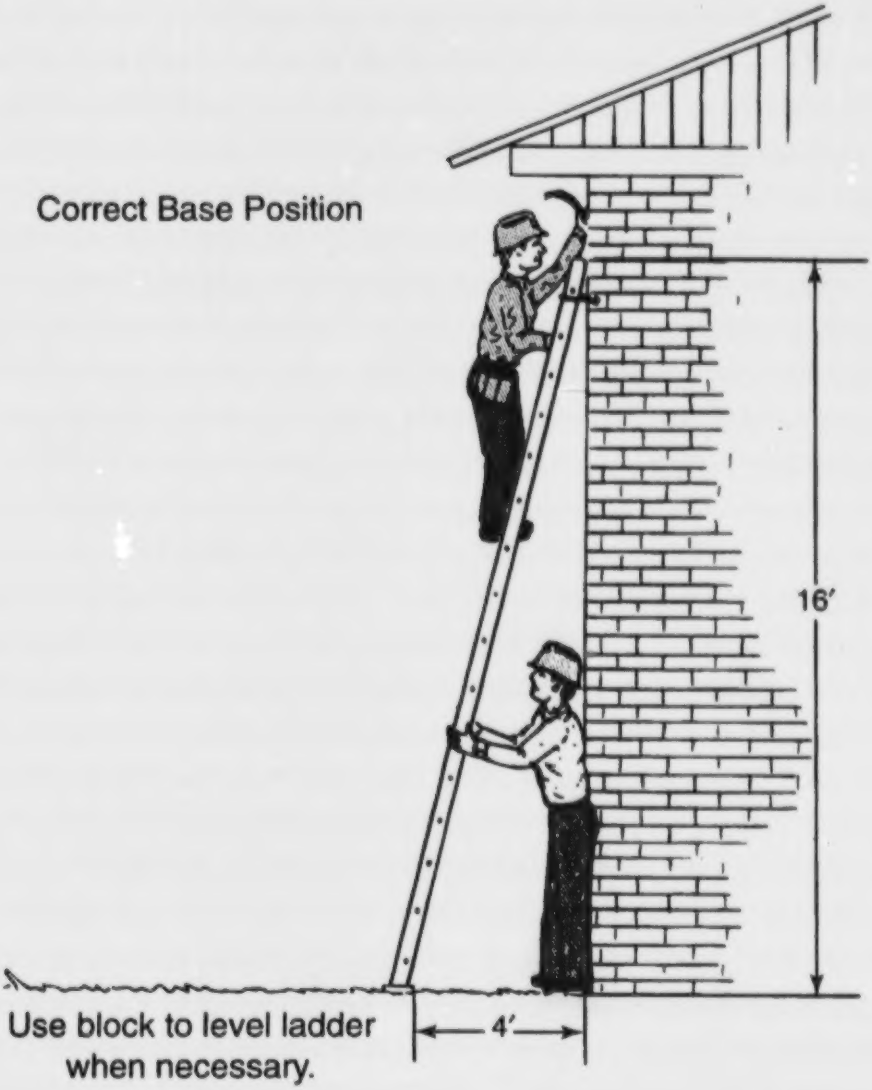


Use block to level ladder
when necessary.

TM 8

Safe Ladder Angle

Correct Base Position

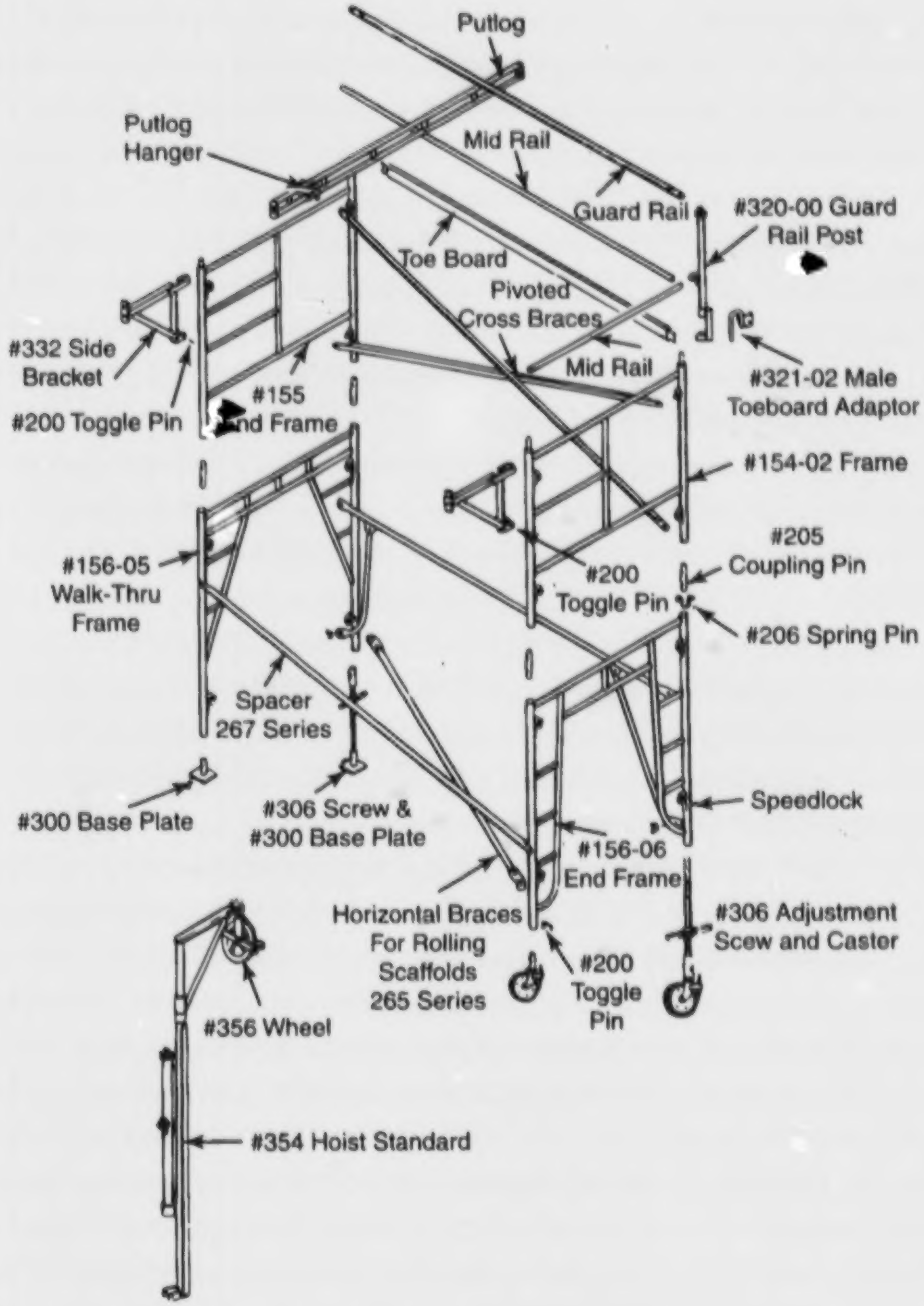


Use block to level ladder when necessary.

Correct base position is 1/4 the vertical height.

TM 9

Scaffold Construction


Putlog
Putlog Hanger
Mid Rail
Guard Rail
#320-00 Guard Rail Post
Toe Board
Pivoted Cross Braces
Mid Rail
#332 Side Bracket
#200 Toggle Pin
#155 End Frame
#321-02 Male Toeboard Adaptor
#154-02 Frame
#205 Coupling Pin
#156-05 Walk-Thru Frame
#200 Toggle Pin
#206 Spring Pin
Spacer 267 Series
Speedlock
#300 Base Plate
#306 Screw & #300 Base Plate
#156-06 End Frame
Horizontal Braces For Rolling Scaffolds 265 Series
#306 Adjustment Scew and Caster
#200 Toggle Pin
#356 Wheel
#354 Hoist Standard

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3–3

Answers to Focus Assignment 3–7

Written Test 3–9

Answers to Written Test 3–15

Transparency Masters

1—Fire Prevention 3–17
2—Electric Shock Versus Body Sensation 3–19
3—Dangers of Rescue Procedures 3–21
4—Dangers of Rescue Procedures (continued) 3–23

Student Components

Student Page

Learning Activities Sheet 3–3

Objective Sheet 3–5

Information Sheet 3–7

Student Supplement

1—Lockout/Tagout Procedures for Electrical Equipment 3–15

* Focus Assignment

Read About Controlling Electrical Hazards 27

* Assignment Sheets

1—Identify and Describe Safety Violations 35
2—Solve Problems Concerning Electrical Safety Practices 37

* Focus Assignment and Assignment Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

- TM1—Fire Prevention (Objective 4)
- TM2—Electric Shock Versus Body Sensation (Objective 10)
- TM3—Dangers of Rescue Procedures (Objective 11)
- TM4—Dangers of Rescue Procedures (Continued) (Objective 11)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

- Demonstrate the proper use of lockout/tagout procedures. Allow students to return your demonstration.

- Demonstrate the function of a ground-fault circuit-interrupter.

- Have students survey the shop area for uses of ground-fault circuit-interrupters.

- Show students how to work safely with live voltages.

- Invite first aid personnel from the local Red Cross or a power supply company to demonstrate rescue procedures for victims 'of electrical shock.

- Invite a member of your local Emergency Medical Service team to speak to the class on precautions that rescuers should take to avoid contaminated body fluids, hepatitis, and AIDS infection when administering first aid.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Early, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993.* Quincy, MA: National Fire Protection Association, 1992.
- Hartman, Lonnie. *Basic Electronics.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1985.
- OSHA Safety and Health Standards. Washington D.C.: U.S. Department of Labor, Occupational Safety and Health Administration.
- *Safety in Electrical Maintenance.* Rockville, MD: NUS Training Corporation, A Halliburton Company.
- Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- Turner, J. Howard. *Understanding Electricity and Electrical Terms.* Athens, GA: American Association for Vocational Instructional Materials.

Suggested Supplemental Resources

Electronic Media

Videotapes

- *Basic Electrical Safety on the Job Site* (10 minutes)

  Meets mandatory training in electrical safety. Explains how to avoid specific electrical hazards.
- *Ground Fault Circuit Interruption* (11 minutes)
  Designed to train all employees in the use of GFCI's and how the system operates. Will increase safety awareness.
- *Hazardous Energy Source–Lockout/Tagout* (10 minutes)
  Mandatory training for both "Affected" and "Authorized" personnel. Describes lockout/tagout, how to control potential machine and equipment accidents that may be started accidentally through a variety of energy sources.

Suggested Activities

Note: Order videos from MAVCC, 1500 West Seventh Avenue, Stillwater, OK 74074-4364, e-mail at mavccweb@okvotech.org, visit their web site at www.mavcc.org, or call (800) 654-3988.

Answers to Focus Assignment

a.
  1. The nature of the substance itself
  2. The length and cross-sectional area of the substance
  3. The temperature of the substance

b. High

c.
  1. The amount of current flowing through the body
  2. The path of the current through the body
  3. The length of time the body is in the circuit

d.
  1. Electrical
  2. Arc
  3. Thermal Contact

e. Thermal Contact

f. Green, White, or Gray

g. Low-Resistance

h.
  1. Fuses
  2. Circuit Breakers
  3. Ground Fault Circuit Interrupters

i. 6

j. 10

Written Test

Name _______________

Date _______________ Score ______

Objective 1

Match the terms related to general safety below with their correct definitions.

1. Ampere
2. Conductor
3. Cube tap
4. Current
5. Ground
6. Grounded
7. Ground-fault circuit-interrupter
8. Hertz
9. Hydraulic
10. Multi-outlet assembly
11. Ohm
12. Pneumatics
13. Volt

_____ a. Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 ampere

_____ b. A system by which equipment is powered by air

_____ c. Unit of measure for electrical current or intensity of electron flow

_____ d. Unit of measure for electrical pressure

_____ e. Unit of measure for electrical resistance

_____ f. One complete positive or negative cycle in an alternating current circuit

_____ g. A type of surface or flush raceway designed to hold conductors and receptacles

_____ h. A device that plugs into a receptacle and provides space for connection of two or more attachment plugs

_____ i. Material through which electrons flow easily

_____ j. Electrical point on any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

_____ k. A system by which equipment is powered by liquid

_____ l. Connected to earth or to some conducting body that serves in place of the earth

_____ m. Electron flow through a conductor

Written Test

Objective 2

List the major causes of electrical accidents.

a. ________________________________

b. ________________________________

c. ________________________________

Objective 3

Select true statements about basic electrical safety practices by placing an "X" in the blanks next to the true statements.

_____ a. Because 110 volts is relatively low, some safety rules can be ignored.

_____ b. Watch out for electrical arcs; they can cause bad burns.

_____ c. Know where all emergency shutdown switches are located.

_____ d. Know that slight overloads are acceptable on some circuits.

_____ e. Never bypass a fuse.

_____ f. Always check a circuit for voltage before servicing.

_____ g. Be sure that all current-carrying electrical lines are well insulated.

_____ h. Watch for burned wires on electrical devices.

_____ i. Operate equipment only 5 percent beyond its rated capacity.

_____ j. Look for cold conductors in electrical systems.

_____ k. Work on live (energized) circuits only when absolutely necessary.

_____ l. Do not operate electrical parts when perspiring.

_____ m. Properly ground all electrical equipment and tools to prevent injury to the operator.

_____ n. Never touch a conductor without first donning insulated or rubber boots.

_____ o. Do not make any adjustment or repairs to any electrical equipment until all power has been disconnected or the electrical breaker has been turned off.

_____ p. Always work alone when working with more than 50 volts.

Objective 4

Select words to complete statements concerning electrical fire prevention practices. Write the correct numbers in the blanks at left.

_____ a. Use extension cords only within their _____.

1. designated rating
2. restricted ohm range
3. recommended hertz cycle
4. rated receptacle designation

_____ b. Never let multi-outlet assemblies or cube taps cause _____.

1. arcing
2. conductance
3. overloads
4. grounding

_____ c. Never use _____ or deteriorated extension cords.

1. insulated
2. frayed
3. wrapped
4. old

_____ d. Never tamper with _____ to change their current-carrying capacity.

1. ground devices
2. monitoring tools
3. breaker boxes
4. fuses

Objective 5

Select true statements about safety practices around live circuits by placing an "X" in the blanks next to the true statements.

_____ a. Use a reliable circuit tester or voltmeter to identify live circuits.

_____ b. Stand on a dry or, at most, a damp surface.

_____ c. Keep both hands on your work whenever possible.

_____ d. Lay out your tools within easy reach of your work.

_____ e. Wear suitable insulated hand covering.

_____ f. Return all tools to your pouch as soon as you are through with them.

Written Test

Objective 6

Select true statements about proper grounding by placing an "X" in the blanks next to the true statements.

_____ a. Always check electrical equipment for proper grounding before working on it.

_____ b. Proper grounding allows the fault current to clear the overcurrent device, thus providing safe operation.

_____ c. Properly grounded equipment provides a pathway for stray current through the operator's body.

_____ d. Loose wires that touch a case or housing in electrical equipment, cannot cause an electrical shock if the equipment has not been properly grounded.

_____ e. Loose connections can be detected by heated or discolored conductors, a burning odor, or carbon tracking.

Objective 7

List facts about the importance of the third wire.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 8

Describe ground-fault circuit-interrupters.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

Objective 9

List instances when lockout devices should be used.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 10

Select words to complete statements about electrical shock. Circle the correct words.

a. High (**current, voltage**) tends to knock the victim away from the circuit, thus minimizing exposure time.

b. High (**current, voltage**). tends to cause the body to adhere to the circuit so that the victim cannot let go.

c. At about (**1,000, 10**) milliamperes, the shock is severe enough to paralyze muscles, and a person may not be able to let go of the conductor.

d. At about (**1, 10**) milliamperes, a slight shock will be felt.

e. At about (**10, 100**) milliamperes, the shock is usually fatal if it lasts 1 second or more.

Objective 11

Select facts about treating a victim of electrical shock. Write the correct numbers in the blanks.

_____ a. What is the first step in rescuing a victim of electrical shock?

1. Treating electrical burn
2. Deenergizing the power source
3. Treating traumatic shock
4. Restoring breathing and/or heartbeat

_____ b. As an extra precaution, and only after the electricity has been turned off, how should the victim of an electrical accident be moved?

1. By pushing the victim with a foot encased in a leather-soled shoe
2. By using a stick, rope, blanket, or other nonconductor to nudge or grasp the victim
3. By standing on a dry surface and jerking the victim quickly away from the electrical source
4. By running at the victim and knocking him or her clear with your body weight.

_____ c. Which of the following tools should be used to turn off electricity at the scene of an electrical emergency?

1. Alligator clip
2. Voltmeter
3. Wood-handled axe or insulated cutters
4. Ground-fault circuit-interrupter

_____ d. Why should the rescuer at an electrical emergency call for assistance?

1. It takes two people to remove a victim from electrical contact
2. One person must perform surveillance on the power source to ensure that it is not reactivated
3. One person can call for medical assistance while the other provides first aid
4. It takes two people to perform the complex first aid measures necessary

_____ e. What should the rescuer do if the victim's pulse is detectable but breathing has stopped?

1. Administer mouth-to mouth resuscitation
2. Administer CPR
3. Administer Heimlich maneuver
4. Administer lung thump

_____ f. What should the rescuer do if the victim's heartbeat has stopped?

1. Administer mouth-to mouth resuscitation
2. Administer CPR
3. Administer Heimlich maneuver
4. Administer lung thump

_____ g. What is the first thing the rescuer should do when treating the victim's electrical burns?

1. Cover his or her own mouth and nose with clean handkerchief
2. Locate and treat both the entrance and exit wounds
3. Apply a cool, clean compress
4. Cover the wound with a sterile, dry dressing

_____ h. In what position should the victim's feet be when being treated for traumatic shock?

1. Level with head
2. Slightly below head level
3. Slightly above head level
4. Knees bent, feet at head level

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 7
b. 12
c. 1
d. 13
e. 11
f. 8
g. 10
h. 3
i. 2
j. 5
k. 9
l. 6
m. 4

Objective 2

a. Rushed or distracted personnel (carelessness)
b. Failure to verify that equipment was deenergized
c. Misuse of tools or equipment

Objective 3

b, c, e, f, g, h, k, m, o

Objective 4

a. 1
b. 3
c. 2
d. 4

Objective 5

a, e, f

Objective 6

a, b, e

Objective 7

Answers should include any three of the following:

a. It is installed for personal protection.
b. It provides an alternate path for current in case of short.
c. It can save a person's life.

Objective 8

Description should include the following points:

a. Are personal safety devices designed to protect individuals or equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 ampere
b. Are required on 15-and20-ampere receptacle outlets used for temporary power supply at construction sites
c. Interrupt flow of current in substantially less time than a normal overcurrent device will

Objective 9

a. Use when more than one power source is present.
b. Always use when hydraulic position could change.
c. Always use when pneumatic position could change.
d. Use to lock off all electrical devices before working on equipment.

Answers to Written Test

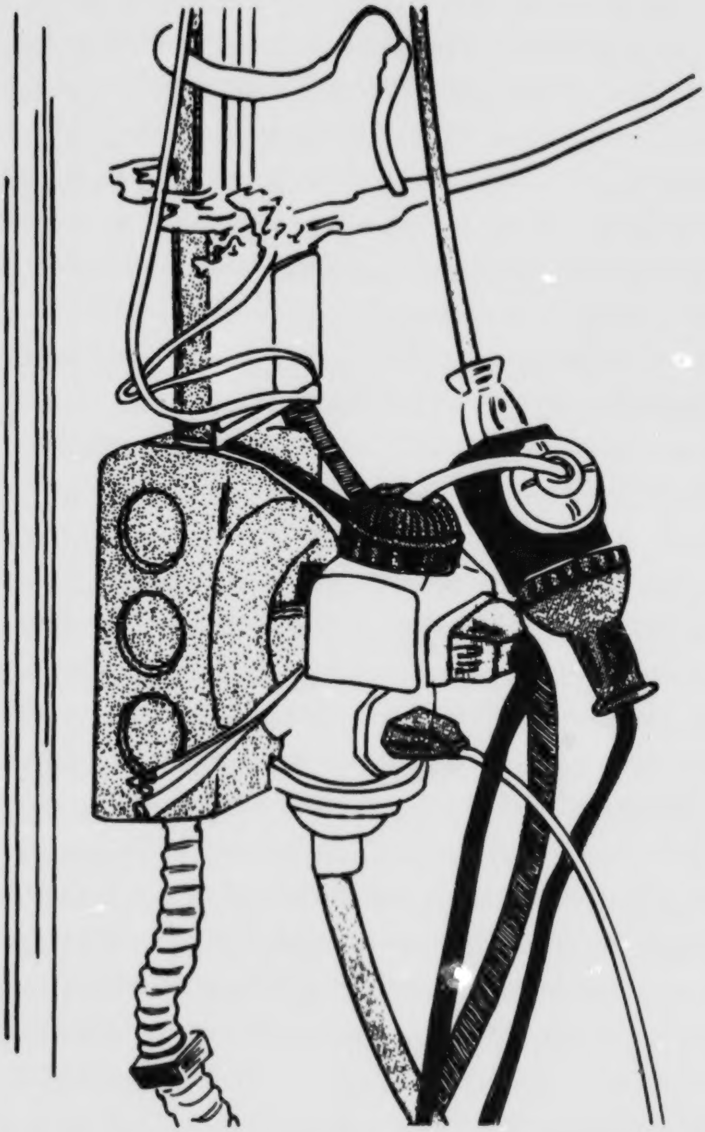
Objective 10

a. Voltage
b. Current
c. 10
d. 1
e. 100

Objective 11

a. 2
b. 2
c. 3
d. 3
e. 1
f. 2
g. 1
h. 3

Fire Prevention



Improper use of electrical equipment is dangerous.

TM 1

Electric Shock Versus Body Sensation

Current Flow Through The Body In Amperes

1.0 Amp	You're Toast
0.50 mA	A 60 Watt Bulb Illuminates
0.30 mA	You're Really Dead
0.10 mA	You're Dead
.058 mA	A 7 Watt Bulb Illuminates
.050 mA	Suffocation Possible
.020 mA	Muscles Contract, Breathing Difficulty
.010 mA	Can't Let Go
.005 mA	GFCI Will Trip
.002 mA	Mild Shock
.001 mA	Threshold of Pain

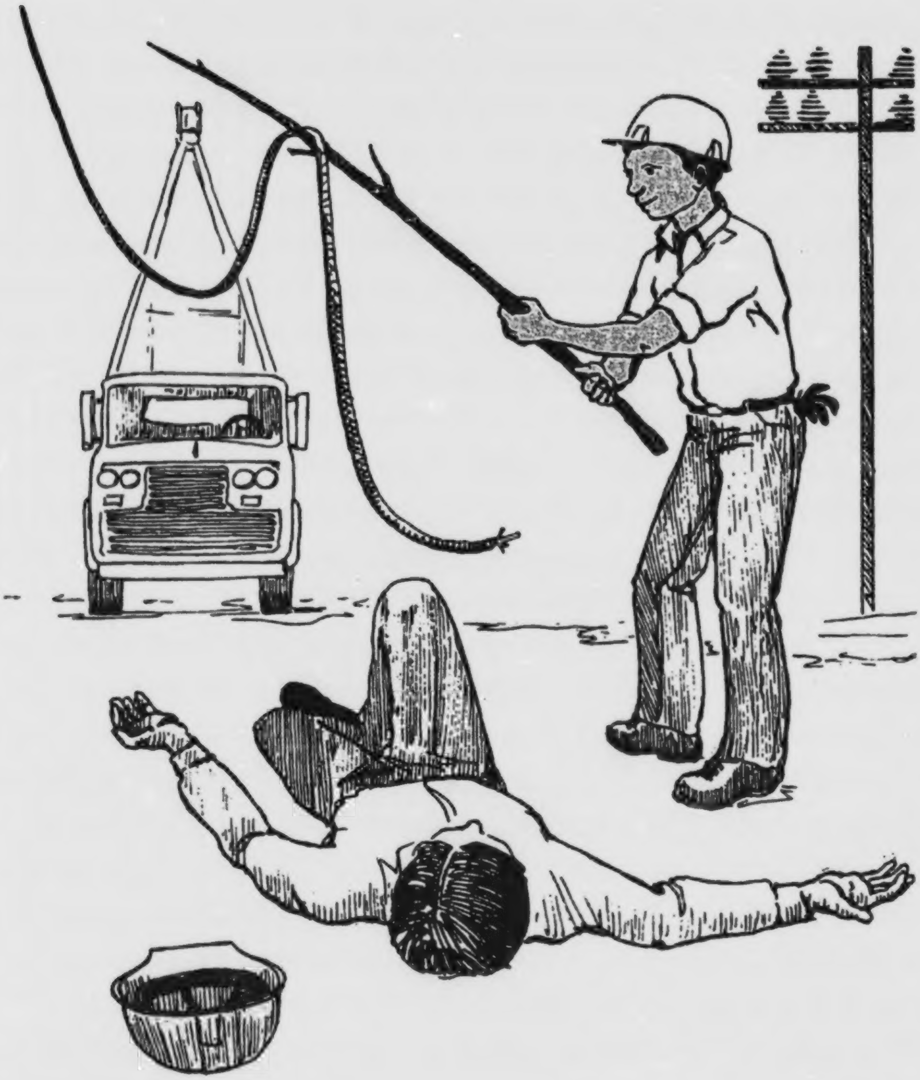
A milliampere (mA) is 1/1,000 of an ampere.

(1,000 mA = 1 A)

1 mA = .001

TM 2

Dangers of Rescue Procedures

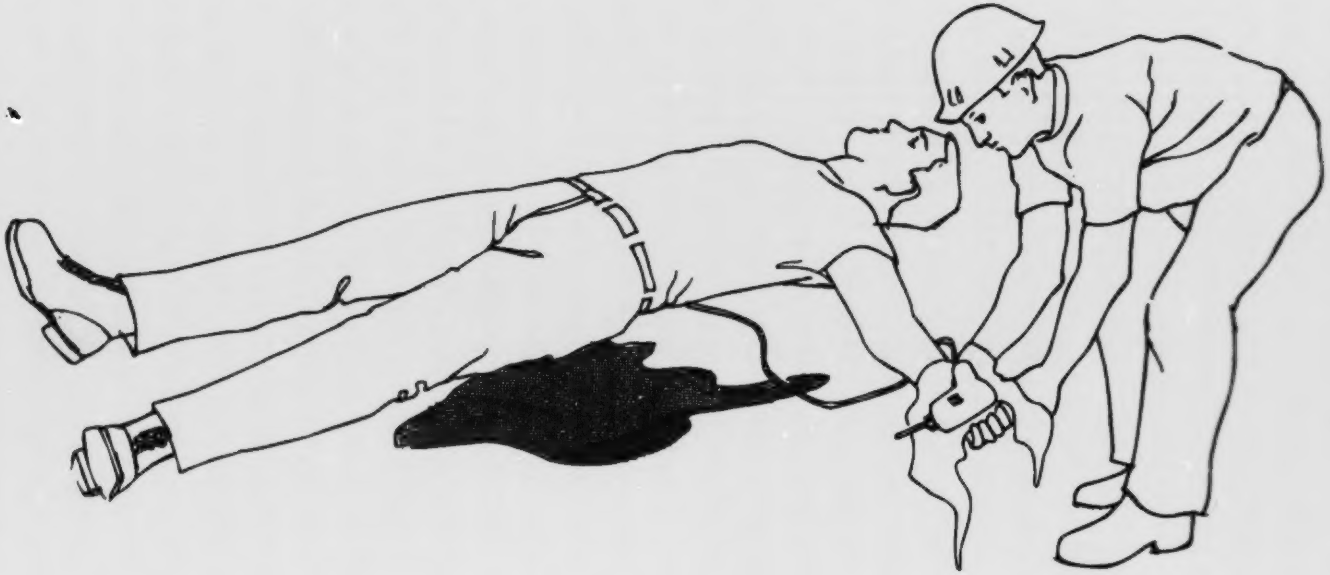


Use a nonconductor to separate victim from electrical circuit.

Do not touch the electrical circuit or the victim unless the power is off or you are insulated.

TM 3

Dangers of Rescue Procedures (continued)



Do not attempt to move a victim
without some form of insulation
such as paper or cloth to protect yourself.

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 4–3

Answers to Assignment Sheets 4–7

Pre-Test 4–15

Written Test 4–27

Answers to Pre-Test 4–41

Answers to Written Test 4–45

Transparency Masters

1—Graduations on a Rule 4–49
2—Graduations on a Rule (continued) 4–51
3—Reading Fourths on a Rule 4–53
4—Reading Eighths on a Rule 4–55
5—Reading Sixteenths on a Rule 4–57
6—Reading Decimal Inches 4–59
7—Reading Measurements on a Metric Rule 4–61

Student Page

Student Components

Learning Activities Sheet 4–3

Objective Sheet 4–7

Information Sheet 4–9

* Assignment Sheets

1—Add Whole Numbers 39
2—Subtract Whole numbers 43
3—Multiply Whole Numbers 47
4—Divide Whole Numbers 51
5—Reduce Fractions to Lowest Terms 55
6—Convert Fractions and Mixed Numbers 57
7—Add Fractions 59
8—Subtract Fractions 63
9—Multiply Fractions 69
10—Add Decimal Numbers 71
11—Subtract Decimal Numbers 75

Unit Contents

12—Multiply Decimal Numbers 79
13—Divide Decimal Numbers 83
14—Convert Fractions and Percentages 87
15—Solve Percentage Problems 91
16—Calculate Area of Geometric Figures 95

* Assignment Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM1 and 2—Graduations on a Rule
TM3—Reading Fourths on a Rule
TM4—Reading Eighths on a Rule
TM5—Reading Sixteenths on a Rule
TM6—Reading Decimal Inches
TM7—Reading Measurements on a Metric Rule

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- If a student has satisfactorily passed in a certain area(s) of the pretest, consider letting him/her skip studying the objective(s) and completing the assignment sheet that pertains to that area.
- Play "You Inherit" with the students to help them learn place values. Ask students to tell you the least amount they inherit when you give them the amount in numbers of digits.

  Examples: Q. "You have just inherited a six-digit sum. What is the least amount you inherit?"

  A. "One hundred thousand dollars."

- On different tables arrange groups of objects such as screws, nails, outlet boxes, pieces of conductor, tools, and so forth to be added, subtracted, multiplied, divided, stated as a percentage, etc. Have students stop at each table and perform the math procedures indicated. Provide each student with a work sheet on which the equations and answers can be written.
- Have students play dominoes. Score ends in multiples of five and play to 250, or score ends at the end of each turn and play to 1,000 points.
- Develop or purchase sets of flashcards for the various math functions. Use the cards to review students in the math functions they need practice with.
- Sit students in a circle. Have all students clap hands twice on legs, then clap hands together twice, then snap fingers twice to establish a rhythm that is to continue unbroken throughout the games. The caller gives a multiplication (or other operation) problem such as 8x6 while snapping fingers, and at the next finger snapping says the name of someone to answer the problem. The responder gives the answer at the next finger snapping without breaking the clap/snap rhythm. If the responder breaks the rhythm or gives an incorrect answer, then he or she is out of the game. The last person left is the winner.

- Have students practice measuring with rules by measuring various items in the classroom or workshop: length of screw, diameter or round box, length of conductor, etc. Have students record their measurements on a sheet of paper, and then have them convert their measurements to improper fractions. After they have improper fractions, have them give their lists to another student who then converts the improper fractions to mixed numbers.

- Assign monetary values to each letter of the alphabet: A=$.05, B=$.10, C=$.15, D=$.25, E=$1.00. . .Z=$20.00. Then have students calculate such problems as who has the most valuable name? What electrical component has the most valuable name/ What electrical tool has the most valuable name?

- Obtain a set of twist drill and a drill index. Take the drills out of the drill index. Have the students replace the drills in the index, noting the decimal and fractional differences in drill sizes.

- Obtain a quantity of pocket-sized decimal equivalent charts from your local tool supplier. Give one to each student.

- Ask students questions based on the tables in Chapter 9 and Annex B of the *National Electrical Code 2002*.

- Illustrate percentages by providing students with graph or grid paper. Have students outline at least eight 10-by-10 block squares. Since each block contains 100 units or small squares, students can shade in enough units to illustrate 25 percent, 33 1/3 percent, 50 percent, 96 percent, and so on.

Evaluation

- Make copies of the pre and post tests. Add or modify test items as needed. The pretest and posttest assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Suggested Activities

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Introduction to Automotive Service*, Unit A-4, "Apply Related Math and Measuring." Stillwater, OK: Curriculum and Instructional Materials Center/Oklahoma Department of Vocational and Technical Education, 1989.

Suggested Supplemental Resources

Print Media

- Kit: *How to Survive Fractions, Decimals, and Percents*

  Note: Print kit includes teacher's guide, two answer key booklets, heavy duty activity cards, and storage case. The software kit includes 400 math work problems in fractions, decimals, and percents to supplement the print kit. Order from EBSCO Curriculum Materials, Division of EBSCO Industries, Inc., Box 281, Chelsea, AL 35043-0281, or call 1-800-633-8623.

Answers to Assignment Sheets

Assignment Sheet 1

Add Whole Numbers

a.

1. 11
2. 16
3. 13
4. 23
5. 108
6. 88
7. 242
8. 1,538
9. 1,197
10. 16,430

b.

1. 20
2. 84
3. 1135
4. $609
5. 86
6. 53
7. 31
8. 423
9. 282
10. 108

Assignment Sheet 2

Subtract Whole Numbers

a.

1. 4
2. 7
3. 53
4. 406
5. 424
6. 283
7. 1,175
8. 1,810
9. 51,450
10. 89,722

b.

1. 126
2. 12
3. 23
4. 948
5. 38
6. 142
7. 210
8. 8
9. 123
10. Week 1 = 780 km
    Week 2 = 1089 km
    Week 3 = 1988 km
    Week 4 = 1089 km
    Week 5 = 1936 km

Assignment Sheet 3

Multiply Whole Numbers

a.

1. 42
2. 72
3. 324
4. 2,884
5. 8,410
6. 2,028
7. 21,291
8. 165,478
9. 503,605
10. 5,458,852

Answers to Assignment Sheets

b.

1. 32
2. 96
3. 3,000
4. 24
5. 128
6. $348
7. 315
8. 135
9. 1,440
10. 15,042

Assignment Sheet 4

Divide Whole Numbers

a.

1. 4
2. 8
3. 91
4. 312
5. 3
6. 3
7. 62, R4
8. 2, R97
9. 1, R365
10. 3, R634

b.

1. 11
2. $22
3. 104
4. 23
5. $936
6. 33

Assignment Sheet 5

Reduce Fractions to Lowest Terms

a. 1/2
b. 1/2
c. 1
d. 1/4
e. 1/4
f. 3/8
g. 1/2
h. 1/2
i. 3/4
j. 1/2

Assignment Sheet 6

Convert Fractions and Mixed Numbers

a.

1. P
2. M
3. I
4. M
5. P
6. I
7. I
8. M
9. I
10. M
11. M
12. I
13. I
14. P
15. M

b.

1. 13/4
2. 9/2
3. 31/4
4. 17/2
5. 49/8
6. 11/2
7. 17/4
8. 17/2
9. 37/4
10. 33/2

c.

1. 1 3/4
2. 4 1/2
3. 1 1/2
4. 1 7/8
5. 1 3/16
6. 1 3/8
7. 2 11/32
8. 2 1/2
9. 3 3/4
10. 2 1/16

Answers to Assignment Sheets

Assignment Sheet 7

Add Fractions

a.

1. 3/4
2. 1 1/2
3. 1/2
4. 1
5. 1 3/16
6. 25/32
7. 29/32
8. 1 1/4
9. 1 5/16
10. 1 25/32

b.

1. 14 3/4
2. 7 3/4
3. 7 3/16
4. 19 5/8
5. 13 1/16
6. 60 1/16
7. 6 13/16
8. 3 1/4
9. 17 1/16

Assignment Sheet 8

Subtract Fractions

a.

1. 9/16
2. 5/8
3. 3/16
4. 5/32
5. 3/4
6. 9/16
7. 1/16
8. 3/8
9. 17/32
10. 1/2

b.

1. 3 1/4
2. 6 1/16
3. 31 19/32
4. 174 1/5
5. 11 3/64

c.

1. 2/3
2. 1 5/8
3. 8 1/8
4. 1 11/32
5. 25 11/16
6. 7 1/4
7. 9/16
8. 1 1/16
9. 2/3
10. 38 9/16

d.

1. 2/5
2. 49 15/16
3. 5 2/3
4. 9 1/2
5. 27 1/8
6. 2 1/4
7. 2 1/8
8. 3 5/16
9. 2 1/2
10. 3 3/16

e.

1. 1/8
2. 3/4
3. 2 7/8
4. 10
5. 1 3/8
6. 6 11/20
7. 3 3/4
8. 8 5/8

Answers to Assignment Sheets

Assignment Sheet 9

Multiply Fractions

a.

1. 3/8
2. 3 3/8
3. 7/12
4. 1/24
5. 15/128
6. 3 1/4
7. 1 13/24
8. 16 27/32

b.

1. 1/4 gallon
2. 74 screws
3. 4 1/3 wires

Assignment Sheet 10

Add Decimal Numbers

a.

1. Tenths
2. Hundredths
3. Hundred thousandths
4. Ten thousandths
5. Thousandths

b.

1. Hundredths
2. Ten thousandths
3. Tenths
4. Thousandths
5. Hundredths

c.

1. 46.3826
2. 35.0038
3. 148.296
4. 6758.23
5. 91.4082
6. 204.37
7. 14.0079
8. 208.097
9. 5.23981
10. 502.967
11. 5230.867
12. 587.029
13. 0.298
14. 329.768
15. 52.694
16. 498.276
17. 0.5296
18. 468.539
119. 324.06
20. 567.8

d.

1. $$\begin{array}{r} 0.024 \\ +\,0.165 \\ \hline 0.189 \end{array}$$

2. $$\begin{array}{r} 87.3 \\ +\,370.0 \\ \hline 457.3 \end{array}$$

3. $$\begin{array}{r} 15.127 \\ 3.4 \\ .0091 \\ +\,236.87 \\ \hline 255.4061 \end{array}$$

4. $$\begin{array}{r} 195.7 \\ 83.0 \\ +\;\;9.006 \\ \hline 287.706 \end{array}$$

5. $$\begin{array}{r} .5280 \\ 435. \\ 179.50 \\ +\;\;1.9 \\ \hline 616.9280 \end{array}$$

e.

1. $39.00
2. $74.33
3. 23.9
4. 20.1
5. $16,018.26

Assignment Sheet 11

Subtract Decimal Numbers

a.

1. 351.98
2. 547.144
3. 141.013
4. 508.16
5. $749.25
6. $4.15
7. 670.4
8. 4,107.34
9. $2.47
10. $197.45

b.

1. $3317.32
2. 14.5
3. 2.84
4. 40.5
5. 27.5

Assignment Sheet 12

Multiply Decimal Numbers

a.

1. 8.184
2. 39.6
3. 1.1475
4. 297.5
5. 100.32
6. 6.4584
7. 0.4565
8. 25.38
9. 0.00069
10. 22.6352

b.

1. $337.45
2. $6187.50
3. .78
4. .28
5. $16.95
6. $18.72
7. 188.6
8. 67.2

Assignment Sheet 13

Divide Decimal Numbers

a.

1. 9
2. 12.4
3. 33
4. 153
5. 1.5
6. 284
7. 0.8
8. 0.5
9. 300
10. .04

b.

1. $8.64
2. 30.3
3. 32
4. $21.60
5. $4.78

Assignment Sheet 14

Convert Fractions and Percentages

a.

1. 0.125
2. 0.25
3. 0.5
4. 0.75
5. 0.625
6. 0.0625
7. 0.09375
8. 0.875
9. 0.5625
10. 0.9375

b.

1. 25%
2. 50%
3. 70%
4. 75%
5. 100%
6. 10%
7. 87.5%
8. 50%
9. 33.3%
10. 62.5%

c.

1. g
2. j
3. d
4. a
5. i
6. b
7. c
8. f
9. h
10. e

d.

1. 63.9
2. 5.93
3. 5.093
4. 5.0093
5. 3.825
6. 38.95
7. 38.095
8. 42.3
9. 402.3
10. 897.00097

e.

1. 1/2
2. 1/4
3. 1/3
4. 9/25
5. 7/25
6. 1/7
7. 21/100
8. 3/4
9. 2/3
10. 7/10

f.

1. .47
2. .15
3. .333
4. .62
5. .75
6. .03
7. .168
8. .09
9. .10
10. .50

Assignment Sheet 15

Solve Percentage Problems

a. All work completed
b. 14%
c. 86, 86%
d. 25%, 5%
e. 94%
f. 6, 6%
g. 89%
h. 94%
i. 40%
j. 50%
k. 5%
l. 38%
m. 25%
n. 60%
o. 7%

p.
1. 2.16
2. 0.9
3. 32
4. 50
5. 43.18
6. 17.6
7. 1.03
8. 57
9. 16.4
10. 11.41

q.
1. 12
2. 1
3. $24.00
4. 600

Assignment Sheet 16

Calculate Area of Geometric Figures

a.
1. 64 square inches
2. 256 square feet
3. 225 square feet
4. 1,296 square yards

b.
1. 60 square feet
2. 192 square yards
3. 527 square inches
4. 992 square feet

c.
1. 113.04 square inches
2. 615.44 square feet
3. 803.84 square feet
4. 490.625 square yards

d.
1. 48 square inches
2. 199.5 square feet
3. 19.5 square inches
4. 180 square yards

e.
1. 12 square feet
2. 104 square yards
3. 256 square inches
4. 243 square yards

g.
1. 493 square inches
2. 242 square yards
3. 168 square feet
4. 765 square yards

Pretest

Name ____

Date ________________________________ Score__________

1 Select correct definitions of math terms. Write a "T" in the blank before each correct definition.

_____ a. **Fraction** is part of a whole; it represents one or more equal parts of a unit.

_____ b. **Digit** is any of the natural numbers, both positive and negative, that represents a complete item.

_____ c. **Subtraction** is the opposite (inverse) operation of addition.

_____ d. **Whole number (integer)** is any of the ten symbols, 0 to 9, by which all numbers can be expressed.

_____ e. **Percent** is a fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number.

_____ f. **Multiplication** is an abbreviated process of adding a number to itself a specified number of times.

_____ g. **Decimal** is one part in a hundred; reckoned on the basis of a whole divided into one hundred parts.

_____ h. **Division** is the opposite (inverse) operation of multiplication.

_____ i. **Liter** is the metric unit used to measure capacity.

_____ j. **Ratio** is being relatively equal in size or quantity.

_____ k. **Addition** is the process of totaling two or more numbers to find another number called a sum.

_____ l. **Meter** is the metric unit used to measure length.

_____ m. **Proportional** is the relationship in quantity, amount, or size between two or more things.

Pre Test

2

Match symbols used in basic math with their correct names. Write the correct numbers in the blanks.

1. .
2. π
3. %
4. :
5. ⟌
6. =
7. x
8. −
9. ÷
10. +

_____ a. Plus sign (addition)

_____ b. Pi sign

_____ c. Equal sign

_____ d. Division frame

_____ e. Ratio symbol

_____ f. Minus sign (subtraction)

_____ g. Percent symbol

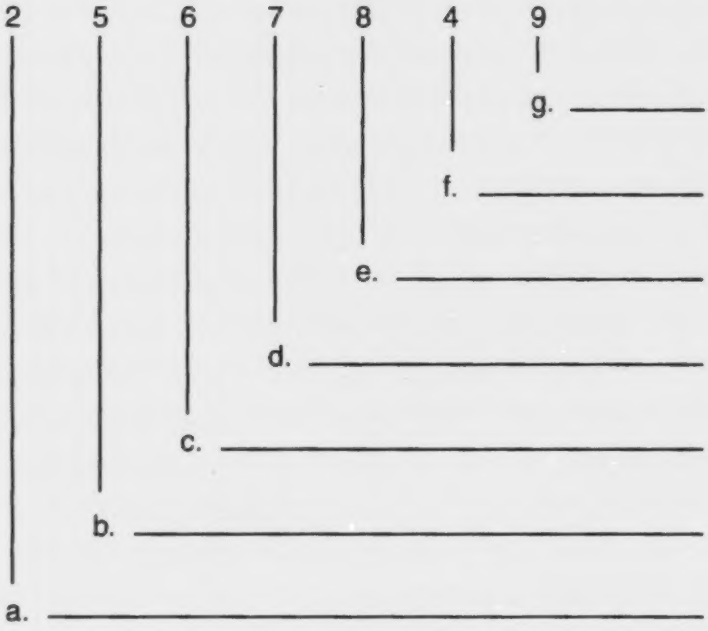
_____ h. Times sign (multiplication)

_____ i. Decimal point

_____ j. Division sign

3

Label the place values in the whole number below.



4 Add whole numbers to solve the following problems.

a. $\begin{array}{r} 7 \\ +\ 11 \\ \hline \end{array}$ b. $\begin{array}{r} 5 \\ 10 \\ +\ 15 \\ \hline \end{array}$ c. $\begin{array}{r} 40 \\ 159 \\ +\ 200 \\ \hline \end{array}$

5 Subtract whole numbers to solve the following problems.

a. $\begin{array}{r} 8 \\ -\ 3 \\ \hline \end{array}$ b. $\begin{array}{r} 47 \\ -\ 22 \\ \hline \end{array}$ c. $\begin{array}{r} 477 \\ -\ 222 \\ \hline \end{array}$

6 Multiply whole numbers to solve the following problems.

a. $\begin{array}{r} 6 \\ \times\ 3 \\ \hline \end{array}$ b. $\begin{array}{r} 75 \\ \times\ 56 \\ \hline \end{array}$ c. $\begin{array}{r} 424 \\ \times\ 138 \\ \hline \end{array}$

7 Divide whole numbers to solve the following problems.

a. $3\overline{)96}$ b. $24\overline{)96}$ c. $135\overline{)541}$

8 Distinguish among types of fractions. Write a "P" in the blanks before the proper fractions, an "I" before improper fractions, and an "M" before mixed numbers.

_____ a. 5/3 _____ c. 20/100 _____ e. 5/5

_____ b. 3/8 _____ d. 1 3/15

9 Reduce the following fractions to lowest terms. Write your answers in the blanks.

_____ a. 2/8 _____ c. 5/25 _____ e. 9/81

_____ b. 4/32 _____ d. 8/32

Pre Test

10 Convert the following mixed numbers to improper fractions. Reduce to lowest terms. Write your answers in the blanks.

_____ a. $2\ ^{1}/_{4}$

_____ b. $6\ ^{7}/_{8}$

_____ c. $15\ ^{5}/_{10}$

11 Convert the following improper fractions to mixed numbers. Reduce to lowest terms. Write your answers in the blanks.

_____ a. $^{27}/_{4}$

_____ b. $^{63}/_{8}$

_____ c. $^{221}/_{6}$

12 Add fractions to solve the following problems. Convert to mixed numbers if necessary, and reduce to lowest terms. Write your answers in the blanks.

_____ a. $^{2}/_{8} + ^{5}/_{8}$

_____ b. $^{7}/_{16} + 5\ ^{1}/_{4}$

_____ c. $4\ ^{1}/_{2} + 8\ ^{1}/_{16}$

13 Subtract fractions to solve the following problems. Reduce to lowest terms. Write your answers in the blanks.

_____ a. $^{5}/_{8} - ^{3}/_{8}$

_____ b. $^{15}/_{16} - ^{3}/_{8}$

_____ c. $3\ ^{5}/_{8} - 2\ ^{3}/_{16}$

14 Multiply fractions to solve the following problems. Reduce to lowest terms. Write your answers in the blanks.

_____ a. $^{3}/_{4} \times ^{5}/_{8}$

_____ b. $^{3}/_{8} \times 5\ ^{1}/_{4}$

_____ c. $8\ ^{1}/_{2} \times 2\ ^{3}/_{4}$

15 Label the place values in the decimal number below.

0.0 8 7 1 6 4

f. ____________

e. ____________

d. ____________

c. ____________

b. ____________

a. ____________

16 Add decimal numbers to solve the following problems. Write your answers in the blanks.

_____ a. $7.32 + $.68 + $4.39

_____ b. 8.40 + 0.87

_____ c. 64.018 + .0473

17 Subtract decimal numbers to solve the following problems. Write your answers in the blanks.

_____ a. $16.20 – $8.10

_____ b. 41.032 – 20.008

_____ c. 0.7964 – 0.4431

18 Multiply decimal numbers to solve the following problems. Write your answers in the blanks.

_____ a. 4.5 x 7.5

_____ b. .248 x 00.45

_____ c. 8.064 x 3.435

19 Divide decimal numbers to solve the following problems. Write your answers in the blanks.

_____ a. 3.15 ÷ 0.7

_____ b. 6.25 ÷ 0.05

_____ c. 72 ÷ .085

20 Convert the following decimal fractions to common fractions. Write your answers in the blanks.

_____ a. .8

_____ b. .35

_____ c. .840

21 Convert the following common fractions to decimal numbers and percentages. Give percentages in the nearest whole percent. Write your answers in the blanks.

Decimals	Percentages		
__________	__________	a.	$^{3}/_{4}$
__________	__________	b.	$^{5}/_{14}$
__________	__________	c.	26 $^{6}/_{100}$

22 Convert the following percentages to fractions and decimal numbers. Write your answers in the blanks.

Decimals	Percentages		
__________	__________	a.	15%
__________	__________	b.	40%
__________	__________	c.	125%

23 Solve the following percentage problems. Write your answers in the blanks.

_____ a. If a contractor paid an electrician $150 which is 80 percent of her salary, how much more money would the contractor still owe?

_____ b. If 15 percent of the fixtures are stolen, how may fixtures will be left of the 2400 stored for the job?

_____ c. If Ed bought equipment for $48,000 and sold it for $60,000 what was his percentage of profit?

24

Match terms used in geometry to their correct definitions. Write "T" or "F" in the blanks.

_____ a. **Cubic unit** is a unit with three equal dimensions including length, width, and height.

_____ b. **Perimeter** is a line or surface at a right angle to another line or surface.

_____ c. **Geometric figure** is a shape formed by straight or curved lines.

_____ d. **Area** is the volume of an object that is 1 foot long, 1 foot wide, and 1 foot high.

_____ e. **Right angle** is an angle formed by two lines perpendicular to each other; it is also a 90-degree angle.

_____ f. **Circumference** is the outer limits of boundary.

_____ g. **Perpendicular** is relating to, consisting of, or resembling a straight line.

_____ h. **Cubic foot** is the measure of a flat surface; it is expressed in square units.

_____ i. **Lineal** is the distance around the outer edge of circle

_____ j. **Parallel** means lines or surfaces extending in the same direction an equal distance apart and never meeting.

_____ k. **Pi** is a Greek letter (π) representing the ratio of a circle's circumference to its diameter; the ratio is approximately 3.1416.

_____ l. **Diameter** is a line form the center of a circle to any point on the edge of a circle.

_____ m. **Volume** is space occupied by a body; it is expressed in cubic units.

_____ n. **Radius** is the distance between the outer edges of a circle through its center point.

Pre Test

25 Match types of geometric figures to their correct descriptions. Select your answer from the three listed and write the correct numbers in the blanks.

_____ a. Figure—such as a square, rectangle, or rhombus—with two parallel ends of equal length and two parallel sides of equal length
  1. Trapezoid
  2. Parallelogram
  3. Rhombus

_____ b. Figure with only one pair of parallel opposite sides
  1. Triangle
  2. Parallelogram
  3. Trapezoid

_____ c. Figure having four sides of equal length and four right angles
  1. Rhombus
  2. Square
  3. Rectangle

_____ d. Flat figure formed by one curved line; all points of a line are an equal distance from the center point
  1. Sphere
  2. Curve
  3. Circle

_____ e. Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles
  1. Rectangle
  2. Square
  3. Rhombus

_____ f. Figure having no right angles and four sides of equal length
  1. Rhombus
  2. Trapezoid
  3. Parallelogram

_____ g. Figure having three sides and three angles
  1. Triangle
  2. Circle
  3. Rhombus

26 Match units of measure to their correct equivalents. Write the correct numbers in the blanks.

1. Yard
2. Mile
3. Degree (°)
4. Foot (′)
5. Inch (″)
6. Rod

_____ a. Equal to twelve inches (12″) or one third of a yard (1/3 yard)

_____ b. Equal to sixteen and one-half feet (16 1/2′)

_____ c. Equal to five thousand, two hundred and eighty feet (5,280′)

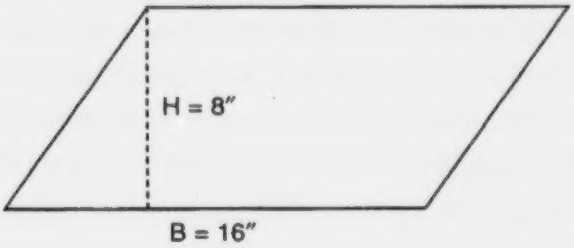
_____ d. Equal to one-twelfth of a foot (1/12′) of one thirty-sixth of a yard (1/36 yard)

_____ e. Equal to three feet (3′) or thirty-six inches (36″)

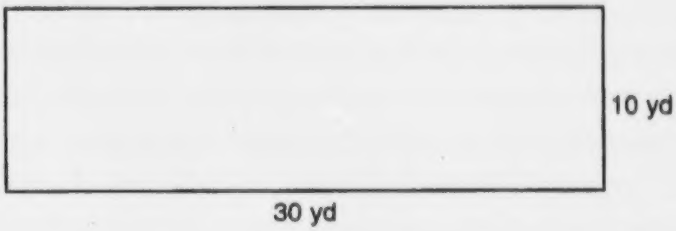
_____ f. Equal to 1/360 of a circle

27 Calculate area of the following geometric figures. Write the correct answers in the blanks.

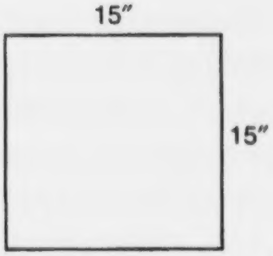
a. ________



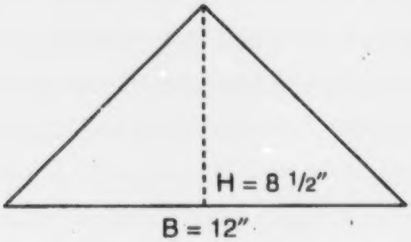
b. ________



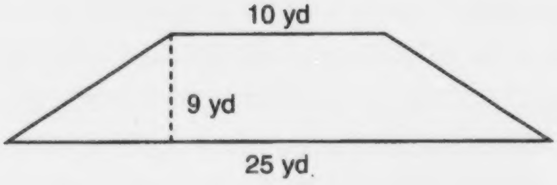
c. ________



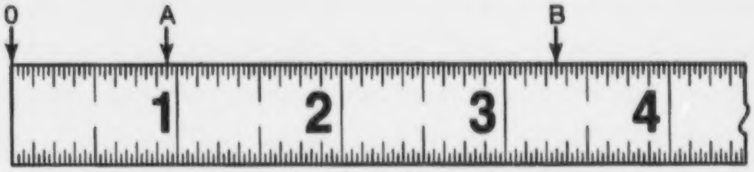
d. ________



e. ________


10 yd
9 yd
25 yd

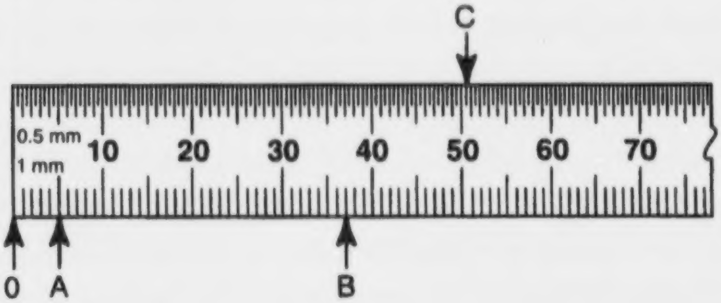
28 Read the rule illustrated below to the nearest sixteenth inch. Write your answers in the blanks provided.



a. 0 to A = _____

b. 0 to B = _____

29 Read the metric rule illustrated below to the nearest 0.5 millimeter. Write your answers in the blanks provided.



a. 0 to A = _____

b. 0 to B = _____

c. 0 to C = _____

30 Solve the following story problems. Write your answers in the blanks.

_____ a. In the first year of operation, an electrical shop handled 1219 jobs. During the second year, the number of jobs increased to 2167. How many more jobs did the shop handle the second year?

_____ b. To install three hanging lights over a kitchen counter takes 65 minutes. If you have already worked 27 minutes, how much longer will you need to work?

_____ c. An electrician has 9 boxes for replacement when needed. He has ordered and received 8 additional boxes. How many total boxes does he have in stock?

_____ d. An electrician ordered the following number of caps at different dates: 256, 62, 575, and 242. How many caps should she be billed for?

_____ e. It takes 35 minutes to wire a fixture in one home. How many minutes does it take to perform the same job on 9 homes?

_____ f. How many 4-conductor ducts can be made using a bundle containing 416 conductors of the desired length?

_____ g. If a can of lubricant holds 5 pounds, how many cans may be filled from a 55-pound drum?

_____ h. There are 500 bolts in a box. How many are in 6 boxes?

_____ i. What is the combined length of two bolts that measure 3 $^1/_2$ inches and 4 $^1/_4$ inches?

_____ j. Samuel worked 4 $^1/_2$ hours before lunch and 4 $^3/_4$ hours after lunch. How many hours did Samuel work?

_____ k. What is the combined length of three tools measuring 2 $^1/_8$ inches, 3 $^1/_4$ inches, and 1 $^{13}/_{16}$ inches?

_____ l. Sarah had a $^7/_8$-inch wrench. She needed a $^3/_4$-inch wrench. How much difference is there in the size of the wrenches?

_____ m. 5 $^1/_4$ hours are how many more that 2 $^1/_2$ hours?

_____ n. If you had to reduce a $^{15}/_{16}$-inch part by $^7/_8$ inch, how much would you have to reduce it?

_____ o. On a lighting job, fixture parts cost $54.65, labor costs $16.30, and tax costs $3.38. What is the total cost of the job?

_____ p. In one month, an electrical repair shop had the following expenses: fixtures and supplies, $429.33; electric bill, $160.16; telephone, $116.27; and labor, $40,312.50. What was the shop's monthly expenditure?

_____ q. An electrical shop received $8438.64 this month and paid out $5121.32. How much profit did the shop make?

_____ r. It takes 20.5 hours to finish a job. Mary has worked 6 hours. How many hours will it take her to finish the job?

_____ s. The average cost of a GFCI installation is $41.25. During the year, the technician installs 150 GFCIs. What was the total cost?

_____ t. A specialist buys 38 box hangers at a cost of $3.49 each. What is the total cost?

_____ u. If a can of lubricating grease costs $6.00 per pound, how much will 58 pounds of grease cost?

_____ v. Naoki received $361.00 for a wiring job. He worked 19 hours on the job. How much money did he make per hour?

_____ w. An apprentice electrician is paid $729.00 for 13.5 weeks of work. Find the average earnings per week for the apprentice.

_____ x. If wiring can be installed in 32 homes in 3.9 days, how many homes can be serviced in 1 day? Round your answer to the nearest tenth.

***Permission to duplicate this test is granted.**

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their correct definitions. Definitions continue on the next page.

1. Digit
2. Multiplication
3. Meter
4. Liter
5. Subtraction
6. Whole number (integer)
7. Addition
8. Fraction
9. Ratio
10. Proportional
11. Division
12. Decimal
13. Percent

_____ a. Process of totaling two or more numbers to find another number called a sum

_____ b. Fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number

_____ c. Any one of the ten symbols, 0 to 9, by which all numbers can be expressed

_____ d. Opposite (inverse) operation of multiplication

_____ e. Part of a whole; represents one or more equal parts of a unit

_____ f. Any of the natural numbers, both positive and negative, that represents a complete item

_____ g. Abbreviated process of adding a number to itself a specified number of times

_____ h. Metric unit used to measure capacity

_____ i. One part in a hundred; reckoned on the basis of a whole divided into one hundred parts

_____ j. Metric unit used to measure length

_____ k. Being relatively equal in size or quantity

_____ l. Relationship in quantity, amount, or size between tow or more things.

_____ m. Opposite (inverse) operation of addition

Written Test

Objective 2

Match symbols used in basic math with their correct names. Write the correct numbers in the blanks.

1. .
2. π
3. %
4. :
5.)‾‾‾
6. =
7. x
8. –
9. ÷
10. +

_____ a. Plus sign (addition)

_____ b. Pi sign

_____ c. Equal sign

_____ d. Division frame

_____ e. Ratio symbol

_____ f. Minus sign (subtraction)

_____ g. Percent symbol

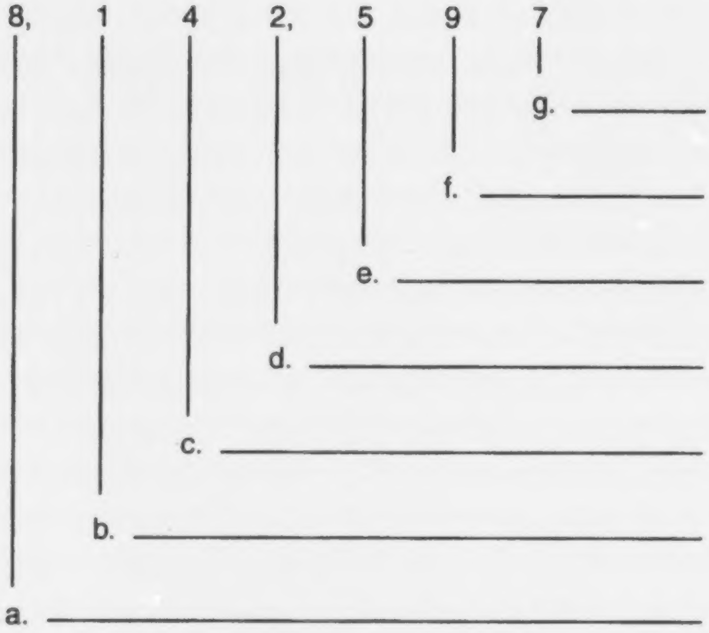
_____ h. Times sign (multiplication)

_____ i. Decimal point

_____ j. Division sign

Objective 3

Label the place values in the whole number below.



Written Test

Objective 4

Add whole numbers to solve the following problems.

a. $\begin{array}{r} 2 \\ \underline{+\,9} \end{array}$ b. $\begin{array}{r} 5 \\ 7 \\ \underline{+\,8} \end{array}$ c. $\begin{array}{r} 12 \\ 17 \\ \underline{+\,99} \end{array}$ d. $\begin{array}{r} 142 \\ 759 \\ \underline{+\,896} \end{array}$ e. $\begin{array}{r} 2345 \\ 9764 \\ \underline{+\,8976} \end{array}$

Objective 5

Subtract whole numbers to solve the following problems.

a. $\begin{array}{r} 9 \\ \underline{-\,7} \end{array}$ b. $\begin{array}{r} 35 \\ \underline{-\,9} \end{array}$ c. $\begin{array}{r} 481 \\ \underline{-\,79} \end{array}$ d. $\begin{array}{r} 684 \\ \underline{-\,342} \end{array}$ e. $\begin{array}{r} 9867 \\ \underline{-\,8748} \end{array}$

Objective 6

Multiply whole numbers to solve the following problems.

a. $\begin{array}{r} 7 \\ \underline{\times\,5} \end{array}$ b. $\begin{array}{r} 68 \\ \underline{\times\,9} \end{array}$ c. $\begin{array}{r} 735 \\ \underline{\times\,68} \end{array}$ d. $\begin{array}{r} 649 \\ \underline{\times 537} \end{array}$ e. $\begin{array}{r} 8673 \\ \underline{\times\,642} \end{array}$

Objective 7

Divide whole numbers to solve the following problems.

a. $4\overline{)48}$ b. $16\overline{)64}$ c. $38\overline{)608}$

d. $421\overline{)842}$ e. $317\overline{)4569}$ f. $530\overline{)80960}$

Objective 8

Distinguish among types of fractions. Write a "P" in the blanks before the proper fractions, an "I" before improper fractions, and an "M" before mixed numbers.

______ a. 1/2

______ b. 8 3/4

______ c. 8/8

______ d. 15 3/8

______ e. 5 3/16

______ f. 10/32

______ g. 2/8

______ h. 6 1/2

______ i. 1/4

______ j. 99/1

Written Test

Objective 9

Reduce the following fractions to lowest terms. Write your answers in the blanks.

_____ a. 4/8

_____ b. 8/16

_____ c. 7/16

_____ d. 8/32

_____ e. 12/32

_____ f. 4/16

_____ g. 2/16

_____ h. 8/64

_____ i. 12/16

_____ j. 31/32

Objective 10

Convert the following fractions and mixed numbers.

a. Convert to improper fractions. Reduce to lowest terms if possible. Write your answers in the blanks.

_____ (1) 3 1/2

_____ (2) 4 2/4

_____ (3) 3 6/8

_____ (4) 12 4/8

_____ (5) 13 13/32

b. Convert the following improper fractions to mixed numbers. Reduce answers to lowest terms. Write your answers in the blanks.

_____ (1) 47/8

_____ (2) 21/9

_____ (3) 108/23

_____ (4) 54/5

_____ (5) 112/7

Objective 11

Add fractions to solve the following problems. Convert to mixed numbers if necessary, and reduce to lowest terms. Write your answers in the blanks.

_____ a. 1/8 + 5/8

_____ b. 1/16 + 15/16

_____ c. 2/4 + 3/4

_____ d. 1/2 + 4/8

_____ e. 4/8 + 2/4

_____ f. 7/8 + 6/16

_____ g. 2 1/8 + 7 1/4

_____ h. 3 2/4 + 16 1/8

_____ i. 4 2/4 + 8 2/8

_____ j. 5 1/8 + 6 2/16

Written Test

Objective 12

Subtract fractions to solve the following problems. Reduce to lowest terms. Write your answers in the blanks.

_____ a. $^{4}/_{8} - ^{3}/_{8}$

_____ b. $^{6}/_{8} - ^{2}/_{8}$

_____ c. $^{9}/_{16} - ^{4}/_{16}$

_____ d. $^{3}/_{8} - ^{1}/_{4}$

_____ e. $^{3}/_{8} - ^{1}/_{8}$

_____ f. $^{14}/_{16} - ^{7}/_{8}$

_____ g. $2\ ^{3}/_{4} - 1\ ^{1}/_{4}$

_____ h. $6\ ^{1}/_{8} - 2\ ^{1}/_{2}$

_____ i. $9\ ^{2}/_{4} - 4\ ^{1}/_{2}$

_____ j. $12\ ^{6}/_{8} - ^{71}/_{8}$

Objective 13

Multiply fractions to solve the following problems. Reduce to lowest terms. Write your answers in the blanks.

_____ a. $^{1}/_{2} \times ^{3}/_{4}$

_____ b. $^{3}/_{4} \times ^{3}/_{8}$

_____ c. $^{3}/_{2} \times ^{1}/_{6}$

_____ d. $^{3}/_{4} \times 6\ ^{1}/_{2}$

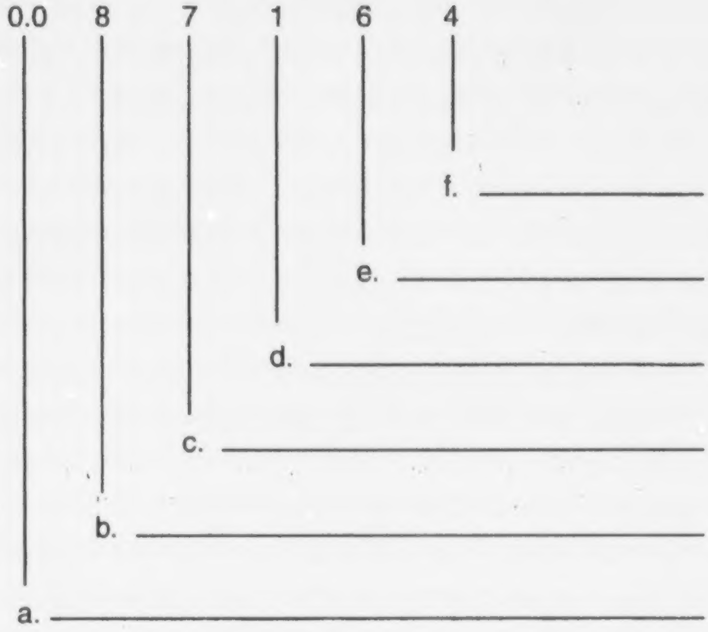
_____ e. $6\ ^{3}/_{4} \times 8\ ^{3}/_{4}$

_____ f. $7\ ^{1}/_{8} \times 1\ ^{1}/_{2}$

_____ g. $^{77}/_{16} \times 5$

Objective 14

Label the place values in the decimal number below.



Written Test

Objective 15

Add decimal numbers to solve the following problems. Set up each problem and show your work. Write your answers in the blanks.

_____ a. 3.5 + 5.1 + 7

_____ b. 3.4 + 0.206 + 1.74

_____ c. $6.86 + $5.05 + $7.90 + $.82

_____ d. 57.78 + 0.22 + 0.003 + 74

_____ e. 6319 + 95.12 + 0.0713 + 321.07

Objective 16

Subtract decimal numbers to solve the following problems. Set up each problem and show your work. Write your answers in the blanks.

_____ a. $6.10 – $2.20

_____ b. $5.40 – $2.32

_____ c. $7.38 – $.63

_____ d. 0.835325 – 0.25

_____ e. 0.609375 – 0.359375

Objective 17

Multiply decimal numbers to solve the following problems. Set up each problem and show your work. Write your answers in the blanks.

_____ a. 2.6 x 4.7

_____ b. 0.119 x 0.05

_____ c. 0 x 0.08

_____ d. 7.392 x 92.07

_____ e. 9.5 x 0.76

Objective 18

Divide decimal numbers to solve the following problems. Set up each problem and show your work. Write your answers in the blanks.

_____ a. 5.32 ÷ 0.4

_____ b. 83.4 ÷ 0.6

_____ c. 7.75 ÷ 0.25

_____ d. 0.921 ÷ 0.3

_____ e. 0.0225 ÷ 0.15

_____ f. 24 ÷ 0.2

_____ g. 54 ÷ 0.09

_____ h. 63 ÷ 0.007

_____ i. 812 ÷ 0.058

_____ j. 4125 ÷ 0.040

Objective 19

a. Convert the following decimal fractions to common fractions. Write your answers in the blanks.

_____ (1) .6

_____ (2) .55

_____ (3) .09

_____ (4) .650

_____ (5) .925

b. Convert the following percentages to fractions and decimal numbers. Write your answers in the blanks.

Fraction	Decimal		
__________	__________	(1)	12%
__________	__________	(2)	30%
__________	__________	(3)	45%
__________	__________	(4)	72%
__________	__________	(5)	250%

Objective 20

Solve the following percentage problems. Write your answers in the blanks.

_____ a. If a contractor paid an electrician $150, which is 87 percent of his salary, how much more money would the electrician have coming?

_____ b. If 12 percent of the fixtures for a job are stolen, how may fixtures will be left of the 2100 stored for the job?

_____ c. If an electrical contractor bought $24,000 worth of equipment and sold it for $30,000, what was her percentage of profit?

Objective 21

Match terms used in geometry with their definitions. Write the correct numbers in the blanks.

1. Perimeter
2. Radius
3. Volume
4. Lineal
5. Parallel
6. Diameter
7. Geometric figure
8. Area
9. Cubic foot
10. Circumference
11. Cubic unit
12. Right angle
13. Pi
14. Perpendicular

_____ a. Volume of an object that is 1 foot long, 1 foot wide, and 1 foot high

_____ b. Shape formed by straight or curved lines

_____ c. Line or surface at a right angle to another line or surface

_____ d. Outer limits of boundary

_____ e. Greek letter (π) representing the ratio of a circle's circumference to its diameter; the ratio is approximately 3.1416

_____ f. Distance around the outer edge of circle

_____ g. Distance between the outer edges of a circle through its center point

_____ h. Measure of a flat surface; expressed in square units

_____ i. Line from the center of a circle to any point on the edge of a circle

_____ j. Relating to, consisting of, or resembling a straight line

_____ k. Line or surface extending in the same direction, an equal distance apart and never meeting

_____ l. Space occupied by a body; expressed in cubic units

_____ m. Angle formed by two lines perpendicular to each other; a 90-degree angle

_____ n. Unit with three equal dimensions including length, width, and height

Objective 22

Match types of geometric figures with their descriptions. Write the correct numbers in the blanks.

1. Circle
2. Parallelogram
3. Trapezoid
4. Triangle
5. Rectangle
6. Rhombus
7. Square

_____ a. Figure having three sides and three angles

_____ b. Figure having four sides of equal length and four right angles

_____ c. Flat, round figure formed by one curved line, all points of which are an equal distance from the center point

_____ d. Figure having no right angles and four sides of equal length

_____ e. Figure with only one pair of parallel opposite sides

_____ f. Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles

_____ g. Figure such as a square, rectangle, or rhombus with two parallel ends of equal length and two parallel sides of equal length

Written Test

Objective 23

Match units of measure to their equivalents. Write the correct numbers in the blanks.

1. Inch (″)
2. Foot (′)
3. Yard
4. Rod
5. Mile
6. Degree (°)

_____ a. Equal to five thousand, two hundred and eighty feet (5,280′)

_____ b. Equal to one-twelfth of a foot ($^{1}/_{12}$′) or one thirty-sixth of a yard ($^{1}/_{36}$ yard)

_____ c. Equal to three feet (3′) or thirty-six inches (36″)

_____ d. Equal to $^{1}/_{360}$ of a circle

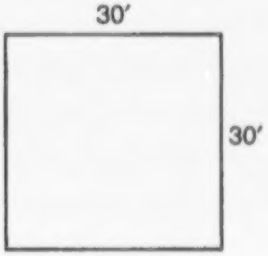
_____ e. Equal to sixteen and one-half feet (16 $^{1}/_{2}$′)

_____ f. Equal to twelve inches (12″) or one third of a yard ($^{1}/_{3}$ yard)

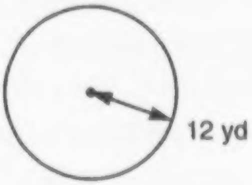
Objective 24

Calculate area of the following geometric figures. Show your work and write the correct answers in the blanks.

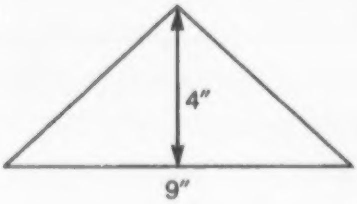
__________ a.



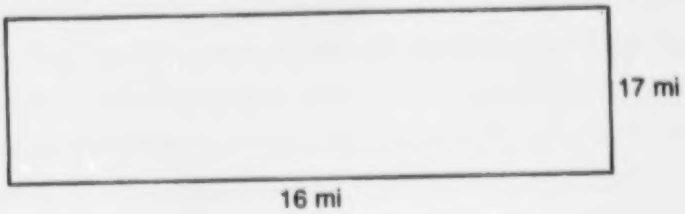
__________ b.



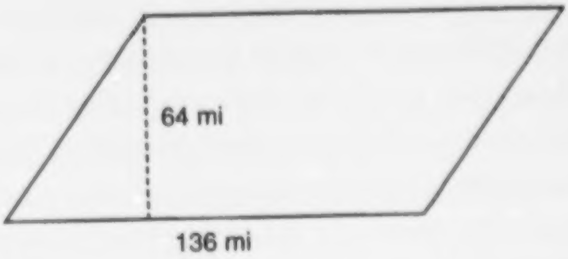
__________ c.



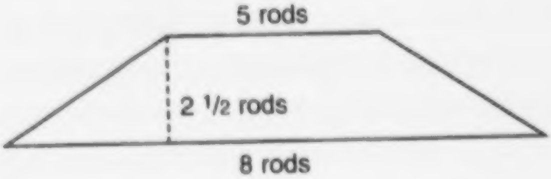
__________ d.



__________ e.



__________ f


5 rods
2 1/2 rods
8 rods

Objective 25

Match metric prefixes with their values. Write the correct numbers in the blanks.

1. kilo- (k)
2. deka- (da)
3. hecto- (h)
4. centi- (c)
5. milli- (m)
6. deci- (d)

_____ a. 100

_____ b. 1/1000

_____ c. 1/100

_____ d. 1/10

_____ e. 10

_____ f. 1,000

Objective 26

Solve problems about English-Metric conversion charts and how to use them. Write the correct numbers in the blanks.

_____ a. If you knew that the conversion factors were 25.4 and you wanted to convert 12 inches to millimeters, you should:

1. Divide 25.4 by 12 to get 2.1 millimeters.
2. Multiply 12 by 25.4 to get 304.8 millimeters.

____ b. If you need to convert meters into feet, you should:

1. Simply find the conversion factor on an English-metric conversion chart, then multiply the meters by the conversion factor.
2. Use an English-metric conversion chart to find the conversion factor for feet, then multiply the feet by the conversion factor.

____ c. In cases, the conversion factor should be used to:

1. Multiply
2. Divide
3. Multiply or divide as the situation requires

***Permission to duplicate this test is granted.**

Answers to Pretest

1 a, c, f, h, i, k, l

2
a. 10
b. 2
c. 6
d. 5
e. 4
f. 8
g. 3
h. 7
i. 1
j. 9

3
a. Millions
b. Hundred thousands
c. Ten thousands
d. Thousands
e. Hundreds
f. Tens
g. Units

4
a. 18
b. 30
c. 399

5
a. 5
b. 25
c. 255

6
a. 18
b. 4200
c. 58512

7
a. 32
b. 4
c. 4 with 1 R

8
a. I
b. P
c. P
d. M
e. I

9
a. 1/4
b. 1/8
c. 1/5
d. 1/4
e. 1/9

Answers to Pre Test

10	a. 9/4 b. 55/8 c. 155/10
11	a. 6 3/4 b. 7 7/8 c. 36 5/6
12	a. 7/8 b. 5 11/16 c. 12 9/16
13	a. 1/4 b. 9/16 c. 1 7/16
14	a. 15/32 b. 1 31/32 c. 23 3/8
15	a. Tenths b. Hundredths c. Thousands d. Ten thousandths e. Hundred thousandths f. Millionths
16	a. 12.39 b. 9.27 c. 64.0653
17	a. $8.10 b. 21.024 c. 0.3533
18	a. 33.75 b. .11160 c. 27.699840
19	a. 4.5 b. 125 c. 847.05882
20	a. 4/5 b. 7/20 c. 21/25
21	a. 0.75; 75% b. .3572; 36% c. 26.06; 2606%

Answers to Pre Test

22

a. 0.15; 3/20
b. 0.40, 2/5
c. 1.25; 1 1/4

23

a. $37.50
b. 2040 fixtures
c. 20 percent

24

a. T
b. F
c. T
d. F
e. T
f. F
g. F
h. F
i. F
j. T
k. T
l. F
m. T
n. F

25

a. 2
b. 3
c. 2
d. 3
e. 1
f. 1
g. 1

26

a. 4
b. 6
c. 2
d. 5
e. 1
f. 3

27

a. 128 sq. in.
b. 300 sq. yd.
c. 225 sq. in.
d. 51 sq. in.
e. 157 1/2 sq. yd.

28

a. 15/16
b. 3 5/16

29

a. 5m
b. 37mm
c. 50.05mm

30

a. 948
b. 38
c. 17
d. 1135
e. 315
f. 104
g. 11
h. 3000
i. 7 3/4
j. 9 1/4
k. 7 3/16
l. 1/8
m. 2 3/4
n. 1/16
o. 74.33
p. 41,018.26
q. $3317.32
r. 14.5
s. $6187.50
t. $132.62
u. $348
v. $19
w. $54
x. 8.2

Answers to Written Test

Objective 1

a. 7
b. 12
c. 1
d. 11
e. 8
f. 6
g. 2
h. 4
i. 13
j. 3
k. 10
l. 9
m. 5

Objective 2

a. 10
b. 2
c. 6
d. 5
e. 4
f. 8
g. 3
h. 7
i. 1
j. 9

Objective 3

a. Millions
b. Hundred thousands
c. Ten thousands
d. Thousands
e. Hundreds
f. Tens
g. Units

Objective 4

a. 11
b. 20
c. 128
d. 1,797
e. 21,085

Objective 5

a. 2
b. 26
c. 402
d. 342
e. 1,119

Objective 6

a. 35
b. 612
c. 49,980
d. 348,513
e. 5,568,066

Objective 7

a. 12
b. 4
c. 16
d. 2
e. 14, R131
f. 152, R40

Objective 8

a. P
b. M
c. I
d. M
e. M
f. P
g. P
h. M
i. P
j. I

Objective 9

a. 1/2
b. 1/2
c. 7/16
d. 1/4
e. 3/8
f. 1/4
g. 1/8
h. 1/8
i. 3/4
j. 31/32

Answers to Written Test

Objective 10

a.	(1)	7/2	(4)	25/2
	(2)	9/2	(5)	429/32
	(3)	15/4		
b.	(1)	5 7/8	(4)	10 4/5
	(2)	2 1/3	(5)	16
	(3)	4 16/23		

Objective 11

a.	3/4	d.	1	g.	9 3/8	j.	11 1/4
b.	1	e.	1	h.	19 5/8		
c.	1 1/4	f.	1 1/4	i.	12 3/4		

Objective 12

a.	1/8	d.	1/8	g.	1 1/2	j.	5 5/8
b.	1/2	e.	1/4	h.	3 5/8		
c.	15/16	f.	0	i.	5		

Objective 13

a.	3/8	e.	59 1/16
b.	9/32	f.	10 11/16
c.	3/32	g.	24 1/16
d.	4 7/8		

Objective 14

a. Tenths
b. Hundredths
c. Thousands
d. Ten thousandths
e. Hundred thousandths
f. Millionths

Objective 15

a.	15.6	d.	132.003
b.	5.346	e.	6735.2613
c.	$20.63		

Objective 16

a.	$3.90	d.	0.585325
b.	$3.08	e.	0.25
c.	$6.75		

Objective 17

a.	12.22	d.	680.58144
b.	0.00595	e.	7.22
c.	0.72		

Objective 18

a.	13.3	d.	3.07	g.	600	j.	103,125
b.	139	e.	0.15	h.	9,000		
c.	31	f.	120	i.	14,000		

Answers to Written Test

Objective 19

a.
- (1) 3/5
- (2) 11/20
- (3) 9/100
- (4) 13/20
- (5) 37/40

b.
- (1) 0.12; 3/25
- (2) 0.30; 3/10
- (3) 0.45; 9/20
- (4) 0.72; 18/25
- (5) 2.50; 2 1/2

Objective 20

a. $22.41
b. 1848 fixtures
c. 20 percent

Objective 21

a. 9
b. 7
c. 14
d. 1
e. 13
f. 10
g. 6
h. 8
i. 2
j. 4
k. 5
l. 3
m. 12
n. 11

Objective 22

a. 4
b. 7
c. 1
d. 6
e. 3
f. 5
g. 2

Objective 23

a. 5
b. 1
c. 3
d. 6
e. 4
f. 2

Objective 24

a. 900 sq. ft.
b. 452. 16 sq. yd.
c. 18 sq. in.
d. 112 sq. mi.
e. 8,704 sq. mi.
f. 16 1/4 sq. rods

Objective 25

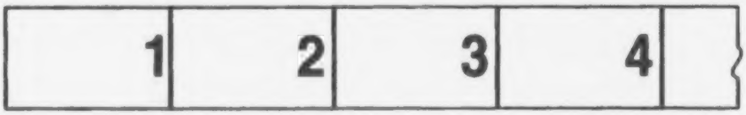
a. 3
b. 5
c. 4
d. 6
e. 2
f. 1

Objective 26

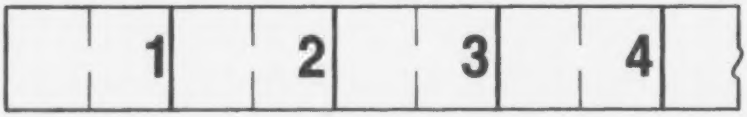
a. 2
b. 1
c. 1

Graduations on a Rule

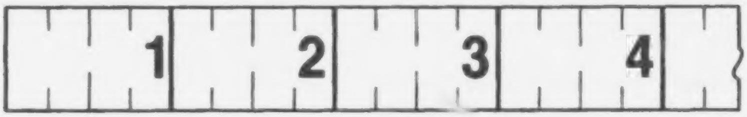
Inches



Halves

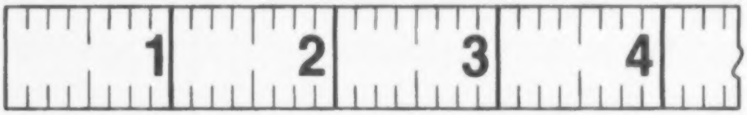


Quarters or Fourths

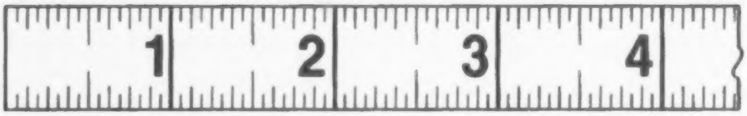


Graduations on a Rule (continued)

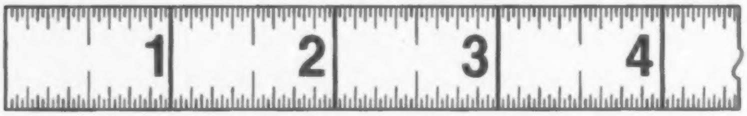
Eighths



Sixteenths

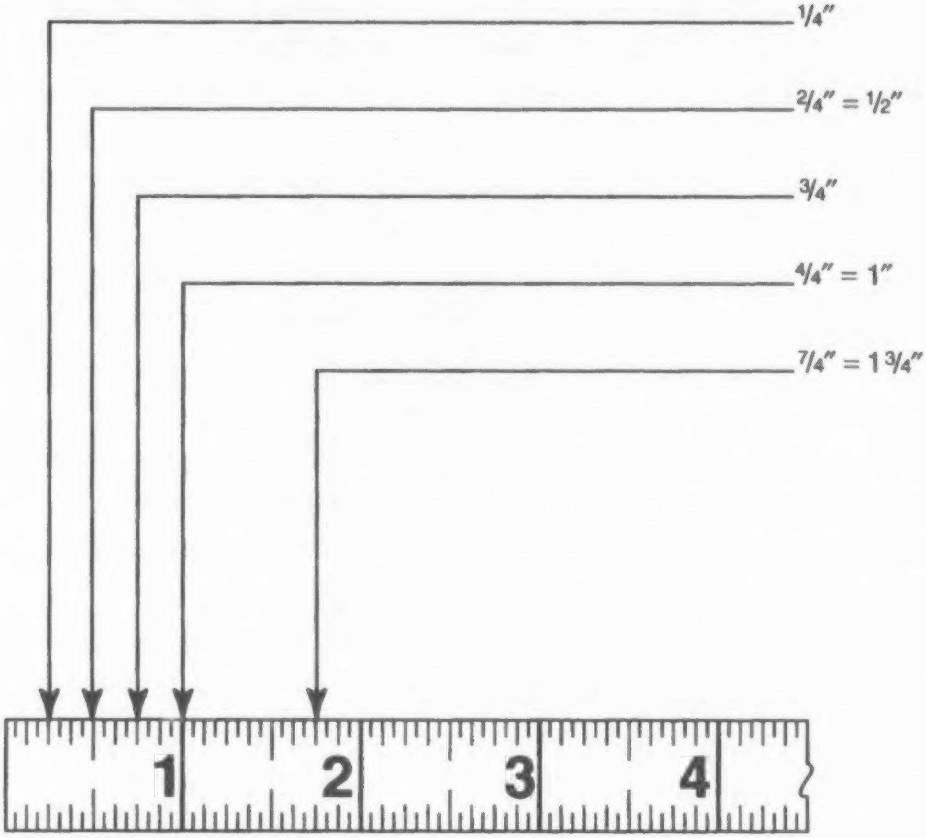


Thirty-Seconds



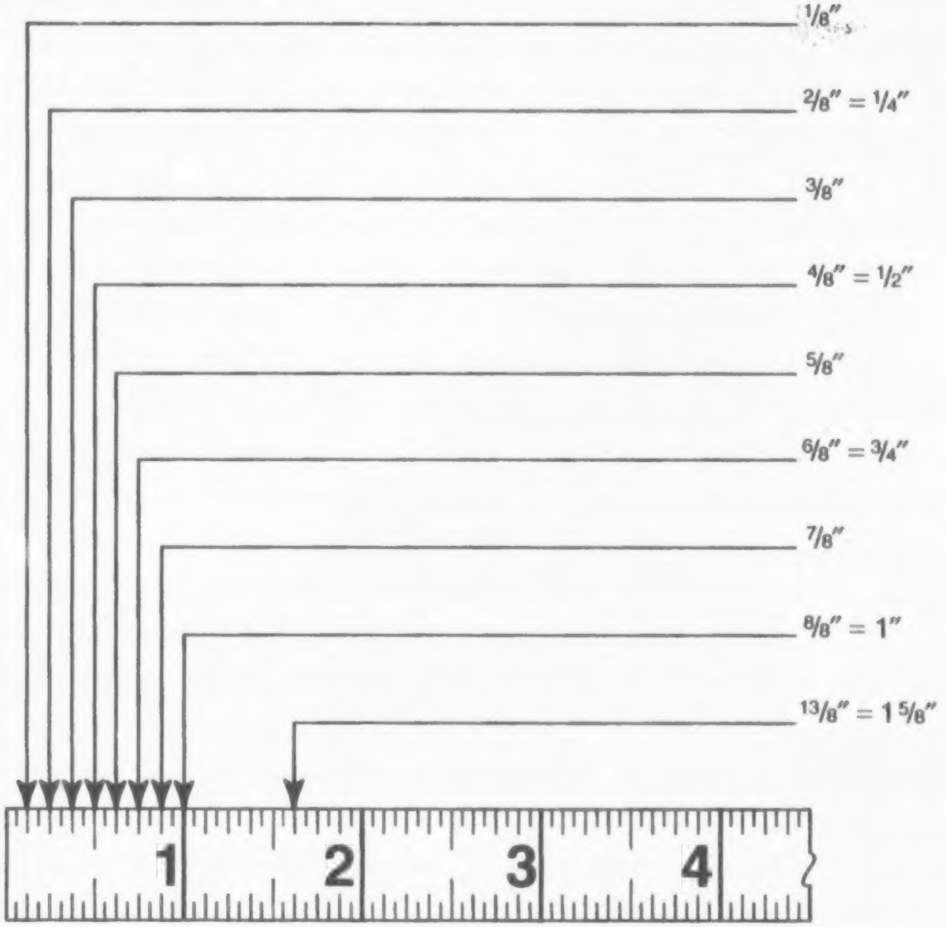
TM 2

Reading Fourths on a Rule

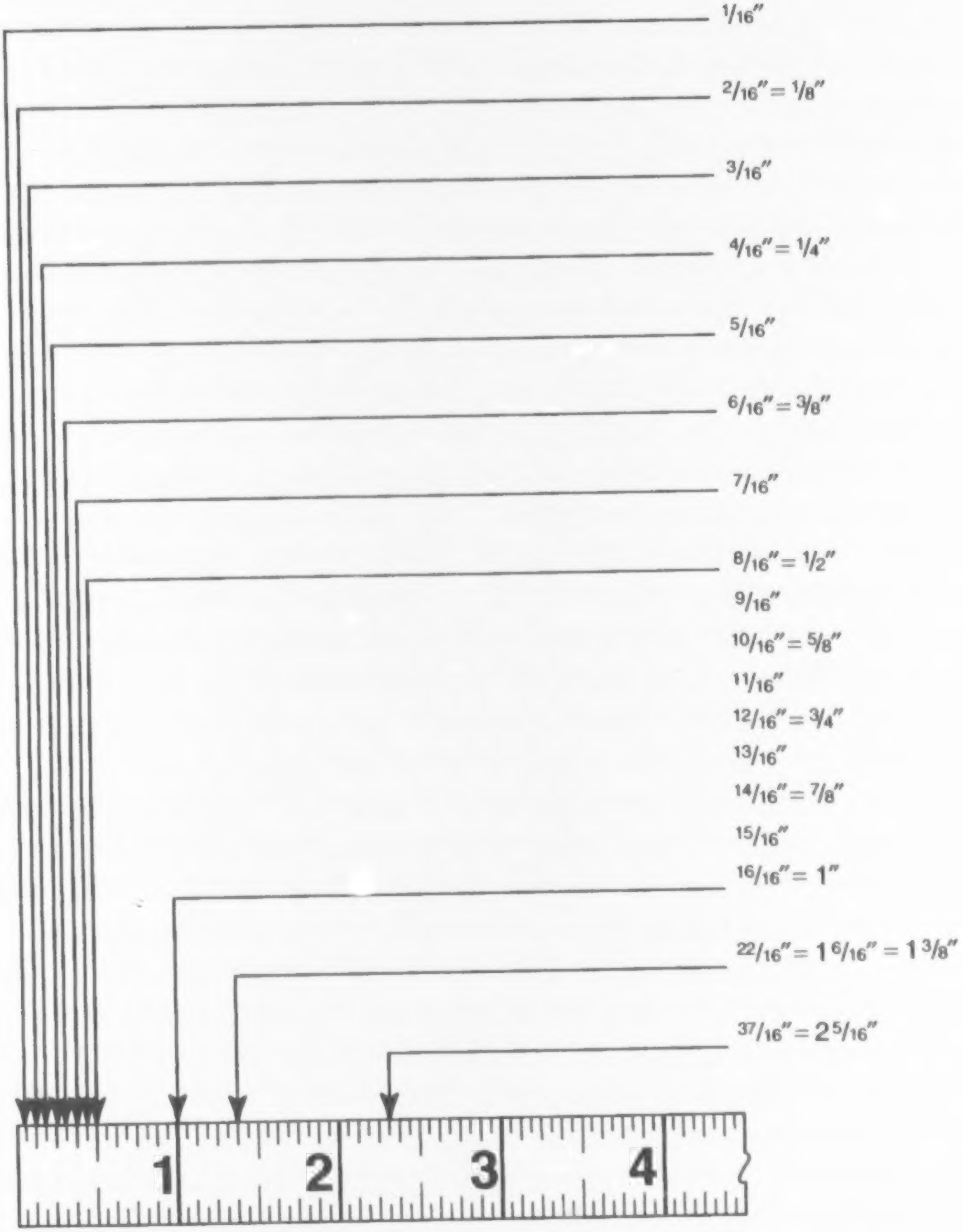

1/4"
2/4" = 1/2"
3/4"
4/4" = 1"
7/4" = 1 3/4"
1
2
3
4

TM 3

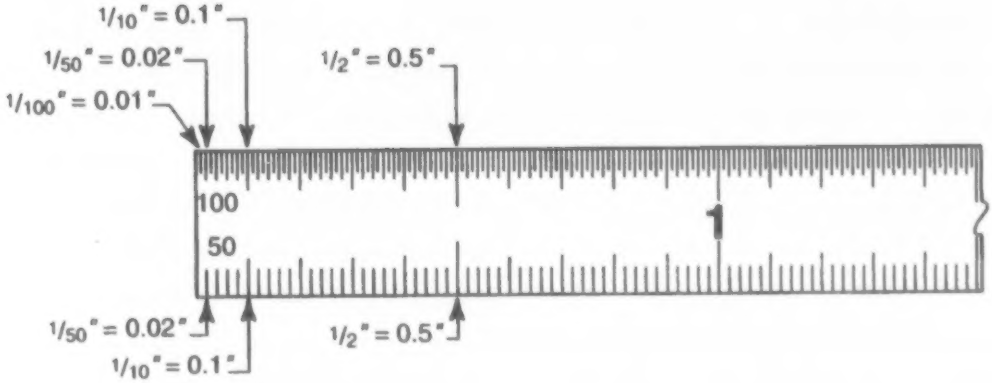
Reading Eighths on a Rule


1/8"
2/8" = 1/4"
3/8"
4/8" = 1/2"
5/8"
6/8" = 3/4"
7/8"
8/8" = 1"
13/8" = 1 5/8"
1
2
3
4

Reading Sixteenths on a Rule

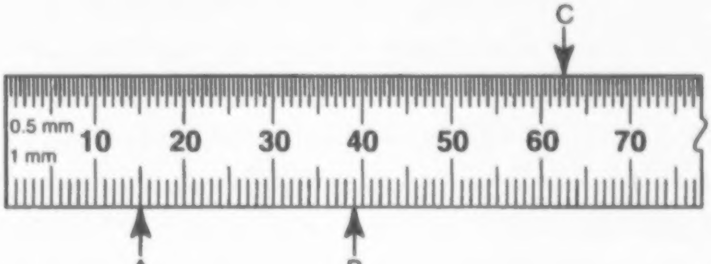

1/16"
2/16" = 1/8"
3/16"
4/16" = 1/4"
5/16"
6/16" = 3/8"
7/16"
8/16" = 1/2"
9/16"
10/16" = 5/8"
11/16"
12/16" = 3/4"
13/16"
14/16" = 7/8"
15/16"
16/16" = 1"
22/16" = 1 6/16" = 1 3/8"
37/16" = 2 5/16"
1
2
3
4

Reading Decimal Inches


1/10" = 0.1"
1/50" = 0.02"
1/100" = 0.01"
1/2" = 0.5"
100
50
1
1/50" = 0.02"
1/10" = 0.1"
1/2" = 0.5"

English rule with decimal graduations in fiftieths and one hundredths

Reading Measurements on a Metric Rule



Metric rule with 1-mm and 0.5-mm graduations

1. Read the measurement to reference point A

   The measurement to reference point A is 10 mm plus 5 mm.

   A = 10 mm + 5 mm = 15 mm

2. Read the measurement to reference point B.

   The measurement to reference point B is 1 mm less than 40 mm.

   B = 40 mm – 1 mm = 39 mm

3. Read the measurement to reference point C.

   The measurement to reference point C is 60 mm plus two 1- mm graduations plus one 0.5-mm graduation.

   C = 60 mm + 2 mm + 0.5 mm = 62.5 mm

TM 7

Unit 5 — Hand Tools

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 5–3

Answers to Assignment Sheets 5–7

Written Test 5–9

Answers to Written Test 5–19

Transparency Masters

1—Using a Channel Lock Wrench 5–21
2—Using a Circuit Tester 5–23

Student Components

Student Page

Learning Activities Sheet 5–3

Objective Sheet 5–5

Information Sheet 5–7

* Focus Assignment

List and Price Electrician's Tools 99

* Assignment Sheet

1—Measure Objects Using a Tape Measure 101

* Job Sheets

1—Clean and Lubricate an Adjustable Hand Tool 105
2—Use a Cutting/Crimping Tool 107
3—Adjust Wire Strippers 111
4—Set Up and Use a Hacksaw to Cut Conduit 113
5—Ream and Thread Rigid Conduit 115
6—Bend EMT Conduit 119
7—Use a Knockout Punch 123
8—Use a Hole Saw 127

* Focus Assignment, Assignment Sheet, and Job Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM1—Using a Channel-Lock Wrench
  TM2—Using a Circuit Tester

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Discuss tool pouch requirements with the students in conjunction with the focus assignment.
- Invite local suppliers to show various tools, and to discuss the advantages and disadvantages of each design. Have students take notes on the discussion.

  Note: Some tool manufacturers, such as Klein Tools (www.kleintools.com), offer tool education seminars that include a training session on hand tools. Klein also offers a 50% discount on tool displays for the classroom, and a 10% discount on products ordered for students in qualifying educational institutions. Contact your local representative for more information.
- Visit local tool suppliers. Have students compare and contrast quality and purposes of tools available to the electrician.
- Demonstrate the proper use and care of basic hand tools. Allow students to return your demonstrations.
- Supplement hand tools as you deem necessary.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheet. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Crost, Terrell, ed. *American Electrican's Handbook,* 11th ed. New York: McGraw-Hill, 1987.

- *Greenlee Tool Catalog.* Rockford, IL: Greenlee Textron, Inc., 1992. Phone 1-800-435-0786.

- *Klein Tools Catalog*. Klein Tools, Inc., 7200 McCormick Blvd., Chicago, IL 60645. Phone (312) 677-9500.
- Siebert, Leo N. *Introduction to Industrial Electricity-Electronics.* Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center.
- Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Supplemental Resources

Electronic Media

- *Hand and Power Tool Safety* (13 minutes)
  Emphasis on individuals responsibility, equipment maintenance, and general safety rules in the use of these tools.
- *Electrical Tools ID* (53 minutes)
  An excellent intro to common tools used in electrical installation and repair. A quiz is included.

Note: Order videos from MAVCC, 1500 West Seventh Avenue, Stillwater, OK 74074-4364, e-mail at mavccweb@okvotech.org, visit their web site at www.mavcc.org, or call (800) 654-3988.

Answers to Assignment Sheets

Assignment Sheet 1

Measure Objects Using A Tape Measure

a. 1. 3″
   2. 1″

b. 1. 3 9/16″
   2. 1 5/8″

c. 1. 7/8″
   2. 2 1/8″
   3. 1 5/16″

d. 1. 2 5/16″
   2. 7/8″
   3. 1 15/16″
   4. 1 1/16″

Written Test

Name ____

Date ______________________________ Score ____________

Objective 1

Match terms related to hand tools with their correct definitions. Write the correct numbers in the blanks.

1. Arbor
2. Cable-tie
3. Chuck
4. Circuit box
5. Conductor
6. Conduit
7. Coupling
8. Fuse
9. Heat shrink
10. Insulation
11. Live circuit
12. Plasterboard
13. Print
14. Snap ring
15. Spaghetti
16. Wire lug

_____ a. Industrial blueprint; industrial wiring diagram

_____ b. Circuit with voltage applied

_____ c. Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

_____ d. Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

_____ e. Device for holding a tool component rigid

_____ f. Nonconductive material placed around a conductor for insulation; does not shrink

_____ g. Box where electrical connections are made, usually through circuit breakers

_____ h. Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

_____ i. Pipe or tube that holds and protects wires or cables

_____ j. Shaft or spindle used to hold a revolving cutting tool or the work to be cut

_____ k. Nonconductive material placed around a conductor for insulation; shrinks when heated

_____ l. Metal ring fastens around or in a shaft to keep other part stationary

_____ m. Mechanical device for connecting conduit and cabling

_____ n. Material through which electrons flow easily; used to connect components

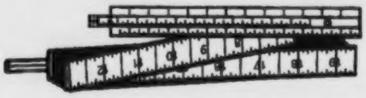
_____ o. Plastic straps with pull-through fasteners for binding together conductors or cables

_____ p. Thin board formed of layers of plaster and paper; Sheetrock

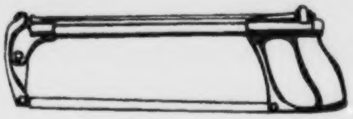
Written Test

Objective 2

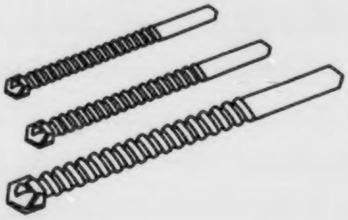
Label the following common hand tools used in the electrical field. Write your answers in the blanks provided.



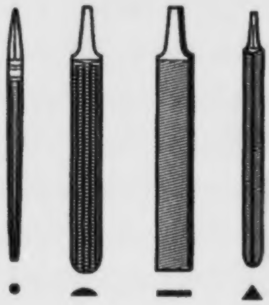
a. ____________________



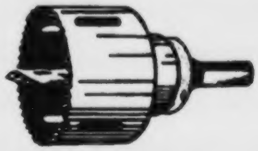
b. ____________________



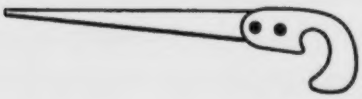
c. ____________________



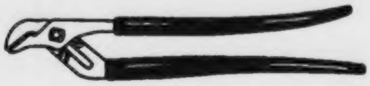
d. ____________________



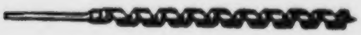
e. ____________________



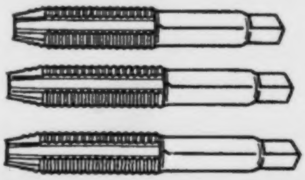
f. ____________________



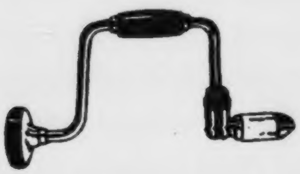
g. ____________________



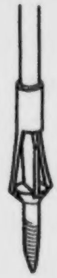
h. ____________________

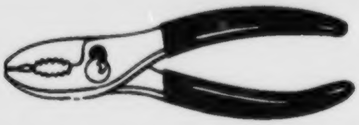


i. ____________________



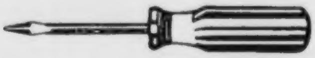
j. ____________________

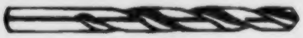




k. ______________________

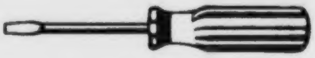
l. ______________________

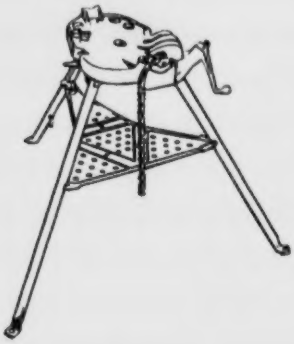




m. ______________________

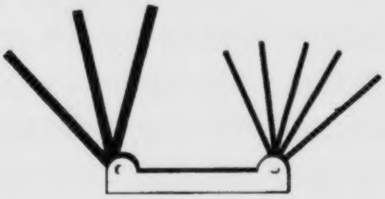
n. ______________________

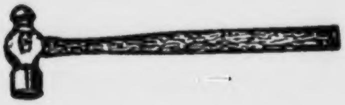




o. ______________________

p. ______________________

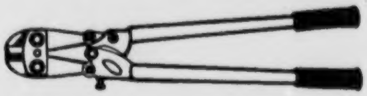




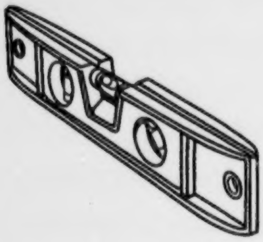
q. ______________________

r. ______________________

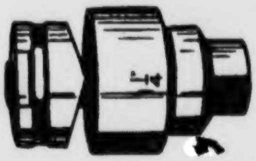
Written Test



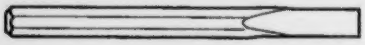
s. ______________________



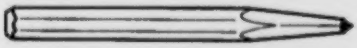
t. ______________________



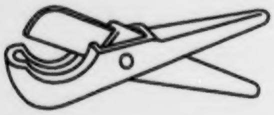
u. ______________________



v. ______________________



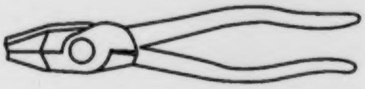
w. ______________________



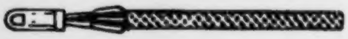
x. ______________________

Objective 3

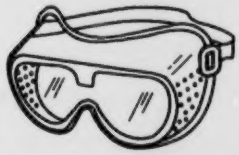
Label the following electricity-specific hand tools used in the electrical field. Write your answers in the blanks provided.



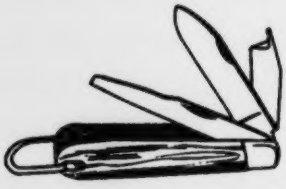
a. ______________________



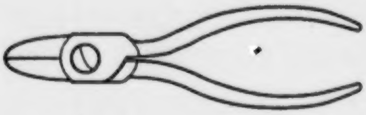
b. ______________________



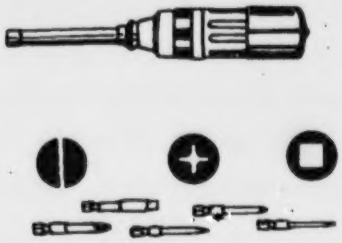
c. ______________________



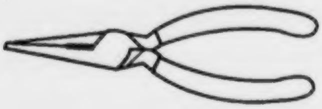
d. ______________________



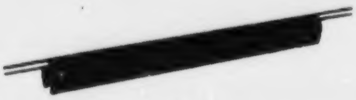
e. ______________________



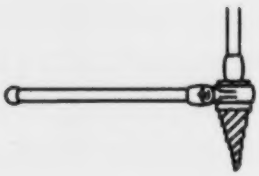
f. ______________________



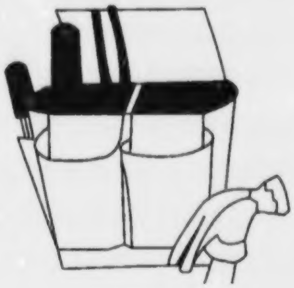
g. ______________________



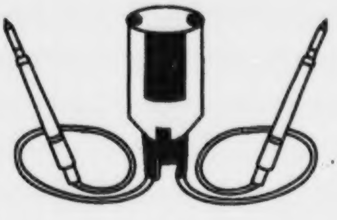
h. ______________________



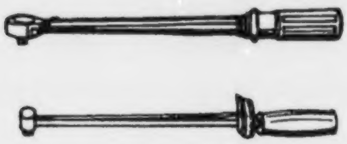
i. ______________________



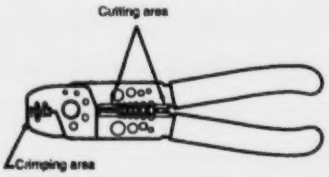
j. ______________________



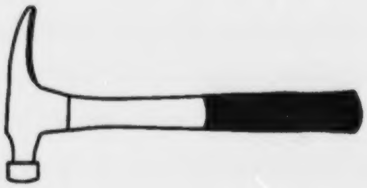
k. ______________________



l. ______________________

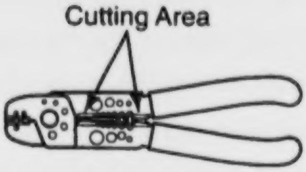

Cutting area
Crimping area

m. ______________________

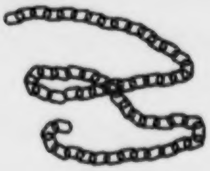


n. ______________________

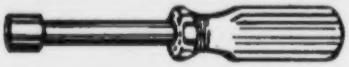
Written Test


Cutting Area

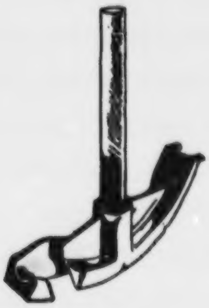
o. ____________________



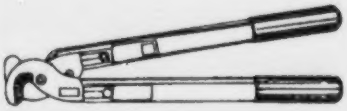
p. ____________________



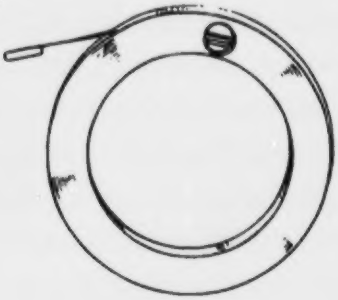
q. ____________________



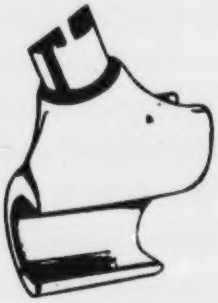
r. ____________________



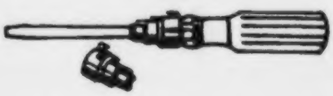
s. ____________________



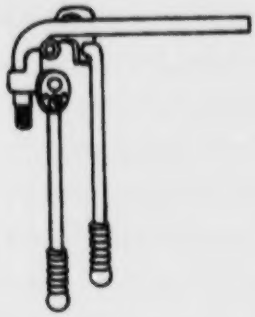
t. ____________________



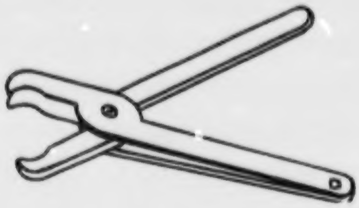
u. ____________________



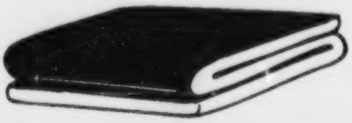
v. ____________________



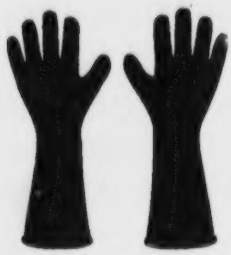
w. ______________________



x. ______________________



y. ______________________



z. ______________________

Objective 4

Match common hand tools with their uses. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Folding rule or tape measure
2. Flat-blade screwdriver
3. Phillips screwdriver
4. Slip-joint pliers
5. Channel-lock wrench
6. Hacksaw
7. Keyhole saw
8. File
9. Chisel
10. Center punch
11. Bolt cutter
12. Hex key set (Allen wrenches)
13. Magnetic torpedo level
14. Knockout punch
15. Hole saw
16. Drill brace and drill
17. Taps
18. Masonry paddle bit
19. Vise stand
20. Screw-holding screw-driver
21. PVC cutter

_____ a. Braces pipe for cutting, reaming, or threading

_____ b. Making center tap for drilling

_____ c. Cutting large holes in metal boxes without drilling

_____ d. Installing and removing slot-head screws

_____ e. Holding and tightening couplings and conductors; holding, tightening, and turning conduit

_____ f. Cutting large conductor or cables, conduit, and metal for electronic cabinets

_____ g. Cutting round holes in masonry

_____ h. Holding screw for use in limited-space installation

_____ i. Boring holes for conduit cable

_____ j. Cutting large bolts, chains, locks, and so forth

_____ k. Leveling conduit and equipment

_____ l. Measuring distances on prints, conduit, cable, and so forth

_____ m. Installing and removing Phillips-head screws

_____ n. Cutting holes in plasterboard for circuit boxes; needs no electric power

_____ o. Installing and removing Allen screws

_____ p. Cutting large holes in metal

_____ q. Retapping damaged threads, equipping drill holes with bolt threads, determining bolt size

_____ r. Notching wood for boxes or cables

_____ s. Gripping and turning work; versatile

_____ t. Deburring large conduit and holes in circuit boxes, sharpening tools, cleaning soldering gun tips and soldering iron

_____ u. Cutting PVC pipe to specific lengths

Written Test

Objective 5

Match the terms with their correct definitions. Definitions continue on the next page.

1. Needle-nose pliers
2. Diagonal pliers (dykes)
3. Lineman's pliers
4. Adjustable wire stripper
5. Cutting/crimping tool
6. Tool pouch
7. Circuit tester
8. Conduit reamer
9. Nut driver
10. Cable bender
11. Fuse puller
12. Safety glasses and goggles
13. Electrician's hammer
14. Cable cutter
15. Drop chain
16. Steel fish tape and reel
17. Pulling grip-sleeve
18. Pipe reamer
19. Conduit bender
20. Hickey bender
21. Electrician's knife
22. Rubber gloves
23. Torque screwdriver
24. Torque wrench
25. Rubber hose (protective sleeve)
26. Rubber blanket

_____ a. Insulating and protecting technician from electrical current

_____ b. Cutting small conductors, cutting conductors in limited spaces

_____ c. Checking circuits for power, checking fuses and breakers

_____ d. Reaming burrs from cut conduits and EMT

_____ e. Tightening Allenhead and bolt-type lugs to manufacturer's specifications

_____ f. Bending heavy conduit

_____ g. Removing fuses safely from equipment and circuit panels

_____ h. Cutting small conductors and bolts, stripping insulation from conductors, crimping wire lugs

_____ i. Protecting eyes from foreign objects and liquids

_____ j. Cutting small conductors, forming loops on small conductors, holding conductors while soldering, stripping insulation from conductors when equipped with #12 stripper

_____ k. Driving and pulling nails, opening wooden crates, breaking plasterboard

_____ l. Pulling in conduit, tray, or overhead lines

_____ m. Cutting large copper or aluminum cables

_____ n. Pulling cables through wall

_____ o. Pulling conductors through conduit, pulling cables through insulated walls

_____ p. Deburring conduit

_____ q. Bending conduit for conductor installation

_____ r. Cutting large conductors, forming loops on large conductors, pulling and holding large conductors

_____ s. Opening paper cartons, stripping large conductors, stripping cables, tightening and loosening small screws when screwdriver not available

_____ t. Protecting wearer against electrical shock when working around energized equipment

_____ u. Installing and removing nuts and bolts, tightening and loosening nuts and long bolts

_____ v. Cutting small conductors, stripping insulation from conductors

_____ w. Tightening slotted lugs and screws to manufacturer's torque specifications

_____ x. Holding and organizing tools

_____ y. Insulating and protecting technician from high-power, uninsulated overhead lines

_____ z. Assisting in bending large cables

Objective 6

List three factors to consider when purchasing hand tools.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 7

Select true statements concerning rules for care of various hand tools by placing an "X" in the blanks next to the true statements.

_____ a. Discard worn or damaged flat-blade screwdrivers.

_____ b. Keep pliers clean and free of dust.

_____ c. Do not lubricate worm gears on adjustable wrenches.

_____ d. Leave cutting edges exposed on cutting tools.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 13
b. 11
c. 16
d. 10
e. 3
f. 15
g. 4
h. 8
i. 6
j. 1
k. 9
l. 14
m. 7
n. 5
o. 2
p. 12

Objective 2

a. Folding rule
b. Hacksaw
c. Masonry paddle bit
d. File
e. Hole saw and arbor
f. Keyhole saw
g. Channel-lock wrench
h. Ship auger drill bit
i Taps
j. Drill brace
k. Screw-holding screwdriver
l. Slip-joint pliers
m. Phillips screwdriver
n. Drill bit
o. Flat-blade screwdriver
p. Vise stand
q. Hex key set (Allen wrenches)
r. Ball peen hammer
s. Bolt cutter
t. Magnetic torpedo level
u. Knockout punch
v. Chisel
w. Center punch
x. PVC cutter

Objective 3

a. Lineman's pliers
b. Pulling grip-sleeve
c. Safety glasses
d. Electrician's knife
e. Diagonal pliers
f. Torque screwdriver
g. Needle-nose pliers
h. Rubber hose
i Pipe reamer
j. Tool pouch
k. Circuit tester
l. Torque wrenches
m. Cutting/crimping tool

Answers to Written Test

n. Electrician's hammer
o. Adjustable wire strippers
p. Drop chain
q. Nutdriver
r. Combination conduit/EMT bender
s. Cable cutter
t. Steel fish tape and reel
u. Hickey bender
v. Conduit reamer
w. Cable bender
x. Fuse puller
y. Rubber blanket
z. Rubber gloves

Objective 4

a. 19
b. 10
c. 14
d. 2
e. 4
f. 6
g. 18
h. 20
i. 16
j. 11
k. 13
l. 1
m. 3
n. 7
o. 12
p. 15
q. 17
r. 9
s. 5
t. 8
u. 21

Objective 5

a. 26
b. 2
c. 7
d. 8
e. 24
f. 20
g. 11
h. 5
i. 12
j. 1
k. 13
l. 17
m. 14
n. 15
o. 16
p. 18
q. 19
r. 3
s. 21
t. 22
u. 9
v. 4
w. 23
x. 6
y. 25
z. 10

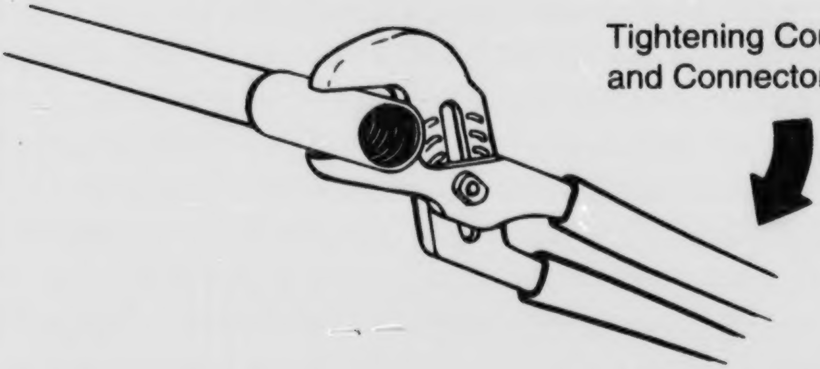
Objective 6

a. Size
b. Design
c. Quality

Objective 7

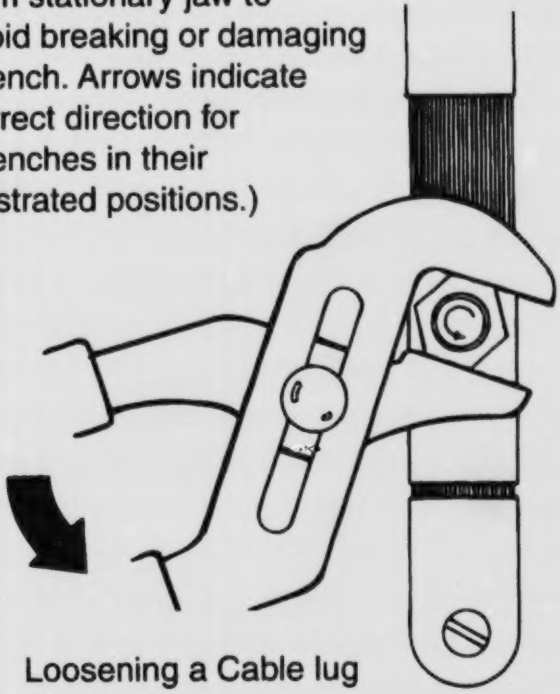
a, b, c

Using a Channel-Lock Wrench



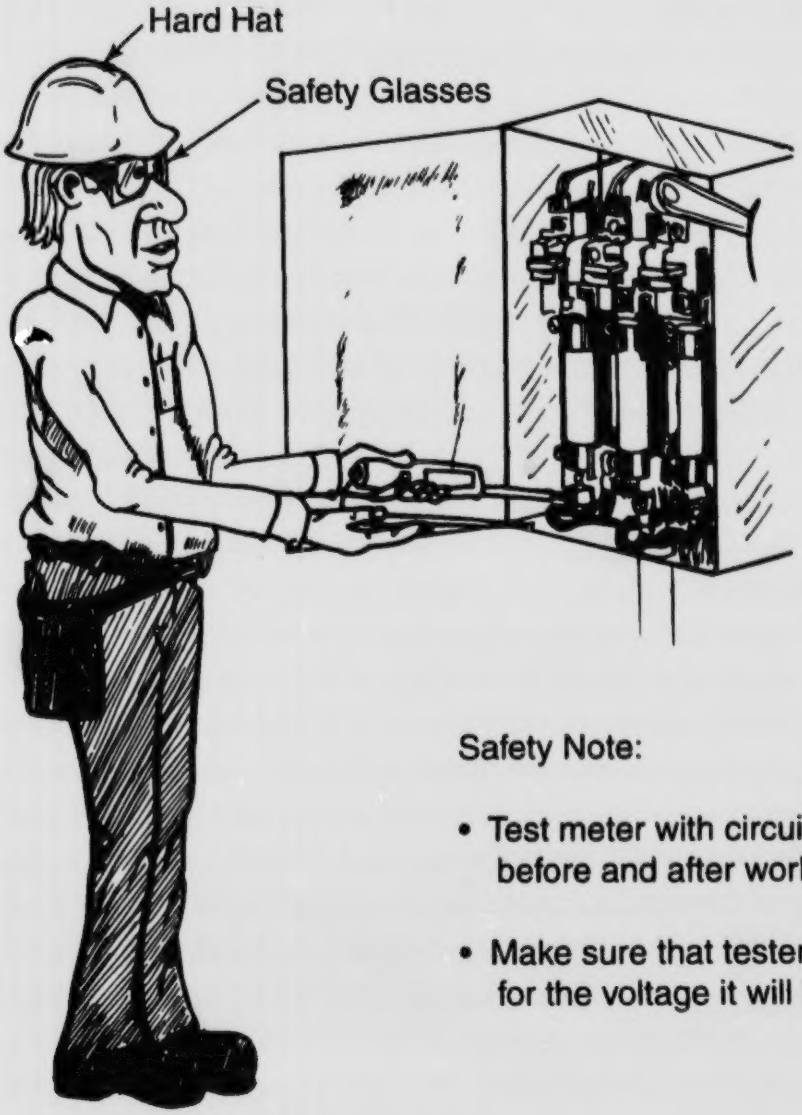
Tightening Couplings and Connectors

(NOTE: Always pull away from stationary jaw to avoid breaking or damaging wrench. Arrows indicate correct direction for wrenches in their illustrated positions.)



Loosening a Cable lug

Using a Circuit Tester


Hard Hat
Safety Glasses

Safety Note:

- Test meter with circuit tester before and after work.
- Make sure that tester is rated for the voltage it will be used on.

Unit 6

Powered/Specialty Tools and Equipment

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 6–3

Answers to Assignment Sheet 6–7

Written Test 6–9

Answers to Written Test 6–23

Transparency Masters

1—Hydraulic Knockout Set 6–27
2—Hydraulic Pipe Bender 6–29
3—PVC Heater and Blanket 6–31
4—Power Drill 6–33
5—Power Cable Puller 6–35
6—Portable and Table Band Saws 6–37
7—Dieless Hydraulic Crimper 6–39
8—Hammer Drill 6–41
9—Core Drilling Machine 6–43
10—Portable Power Threader 6–45
11—Architect's Scale 6–47
12—Voltage Measurement Techniques 6–49
13—Permanent Magnet Moving Coil Multimeter 6–51
14—Correct Voltage Measurements 6–53
15—Amperage Measurement Techniques 6–55
16—Clamp-on Ammeter 6–57
17—Determining Current of a Multiple Loop Using a Clamp-on Ammeter 6–59

Student Components

Student Page

Learning Activities Sheet 6–3

Objective Sheet 6–7

Information Sheet 6–9

* Assignment Sheet

1—Determine Dimensions on a Drawing Using an Architect's Scale 129

Unit Contents

* Job Sheets

1—Use a Hydraulic Knockout Punch 133
2—Bend a 90-Degree Stub Using a Hydraulic Pipe Bender 137
3—Make Offset and 90-Degree Bends Using an Electric PVC Heater 139
4—Cut, Ream, and Thread Rigid Conduit with a Power Threader 145
5—Measure Resistance Using a VOM 149
6—Measure DC Voltages using a VOM 151
7—Measure AC Voltages using a VOM 153
8—Measure Amperage Using a Clamp-on Ammeter 157
9—Determine Current of a Multiple Loop Using a Clamp-on Ammeter 159
10—Check Conductor Insulation with a Megger 161

* Assignment Sheet and Job Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM1—Hydraulic Knockout Set (Objective 6)
TM2—Hydraulic Pipe Bender (Objective 8)
TM3—PVC Heater and Blanket (Objective 10)
TM4—Power Drill (Objective 12)
TM5—Power Cable Puller (Objective 14)
TM6—Portable and Table Band Saws (Objective 16)
TM7—Dieless Hydraulic Crimper (Objective 18)
TM8—Hammer Drill (Objective 20)
TM9—Core Drilling Machine (Objective 22)
TM10—Portable Power Threader (Objective 24)
TM11—Architect's Scale (Objective 26)
TM12—Voltage Measurement Techniques (Objective 27)
TM13—Permanent Magnet Moving Coil Multimeter (Objective 27)
TM14—Correct Voltage Measurements (Objectives 34 and 35)
TM15—Amperage Measurement Techniques (Objectives 27 and 36)
TM16—Clamp-on Ammeter (Objectives 27 and 36)
TM17—Determining Current of a Multiple Loop Using a Clamp-on Ammeter (Objectives 27 and 36)

Suggested Activities

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Invite a local electrical tool salesperson to show powered/specialty tools and equipment to the class.
- Obtain tool catalogs from various suppliers. Encourage students to compare tools and prices.
- Obtain test equipment catalogs from various suppliers. Encourage students to compare test equipment and prices.
- Discuss with the class the proper care and maintenance of specialty tools, power equipment, and test equipment.
- Meet individually with students to evaluate their progress through this unit of instruction, and to indicate to them possible areas of improvement.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

Suggested Activities

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Grainger Industrial and Commercial Equipment and Supplies General Catalog No. 380*. W.W. Grainger, Inc., 1991.
- *Greenlee Products for Electrical, Electronics, HVAC, Utility, and Plant Maintenance:* Tools, Testers, and Accessories Catalog. Rockford, IL: Greenlee Textron/Subsidiary of Textron, Inc., September 1991.
- *Ridgid Catalog No. RT - 191*. Elyria, OH: Rigid Tool Company, 1991.
- Siebert, Leo N. *Introduction to Industrial Electricity-Electronics*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center.
- Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.
- *Using Electrical Test Equipment*. Rockville, MD: NUS Training Corporation, A Halliburton Company.

Suggested Supplemental Resources

Print Media

- Grainger General Catalog. W.W. Grainger, Inc.

  Order from 4314 Will Rogers Parkway, Oklahoma City, OK 73108, or from any Grainger branch office. http://www.grainger.com
- Simpson, James G. *Common Sense Conduit Bending and Cable Tray Techniques*. Delmar Publishers, Inc. 1996.
- Greenlee Products Catalog. Rockford, IL: Greenlee Textron/Subsidiary of Textron, Inc.

  Order from Greenlee/Textron Inc., 4455 Boeing Avenue, Rockford, IL 61109-2988 or call 1-800-435-0786, http://greenlee.textron.com
- Ridgid Catalog. Elyria, OH: Ridge Tool Company

  Order from Ridgid Tool Company, 400 Clark Street, Elyria, OH 44036-2023, http://www.ridgid.com

Answers to Assignment Sheet

Assignment Sheet 1

Determine Dimensions on a Drawing Using an Architect's Scale

Note: Students' answers may vary slightly from these due to variations in printing.

1. 51′–2″
2. 27′–1″
3. 6′–10″
4. 17′–3″
5. 21′–7″
6. 29′–7″
7. 4′–1″
8. 16′–5″
9. 11′–4″
10. 8′–0″
11. 16′–0″
12. 35′–4″
13. 13′–11″
14. 9′–5″
15. 16′–8″
16. 4′–1″
17. 12′–7″
18. 15′–9″
19. 2′–9″
20. 14′–6″
21. 56′–8″
22. 16′–0″
23. 13′–11″

Written Test

Name ______________________________

Date ______________________ Score__________

Objective 1

Match the terms with their correct definitions. Definitions continue on the next page.

1. Accuracy
2. Amperage
3. Bender
4. Calibration
5. Chuck
6. Cross handle (T-handle)
7. Cutter
8. Die
9. Error
10. Ground
11. Hydraulic
12. Hydraulic oil
13. Knockout punch
14. Multimeter
15. Parallax correction
16. Pinch point
17. Polyvinylchloride (PVC) conduit
18. Precision
19. Ram
20. Resistance
21. Resolution
22. Voltage

_____ a. Electromotive force (emf) that drives electricity through conductors; must be measured across or referenced to a second point

_____ b. Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another

_____ c. Device used to transfer hydraulic pressure to a mechanical device

_____ d. How well an instrument will indicate a small change in the measured value

_____ e. Instrument consistency

_____ f. Instrument capable of measuring a "multiple" of values

_____ g. Any opening that may close and bind a finger or hand

_____ h. Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

_____ i. Plastic pipe

_____ j. Device used to make openings for conduit in metal enclosures

_____ k. Component that backs up cutter on opposite side of metal box

_____ l. How far a measurement is from the actual value

_____ m. Portion of drill that holds the bit

_____ n. Tool used to make various angles or bends in conduit

_____ o. Electricity; electrical current flow; electron flow; must be measured at a point within a circuit

_____ p. How near the instrument reading is to the actual value

_____ q. Handle set across a power tool to prevent the tool from turning

_____ r. Hardened steel device used to cut holes in metal boxes

_____ s. Techniques of testing and adjusting an instrument by referring it to another instrument or device of known accuracy and precision

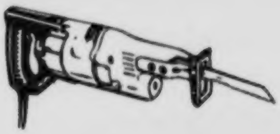
_____ t. Using pressurized fluid to accomplish work

_____ u. Specially formulated oil for hydraulic pumps

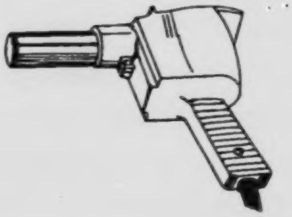
_____ v. Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

Objective 2

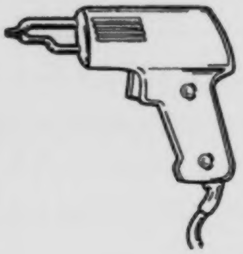
Label the following common powered tools used in the electrical field. Write your answers in the blanks provided.



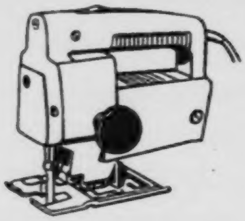
a. ______________________



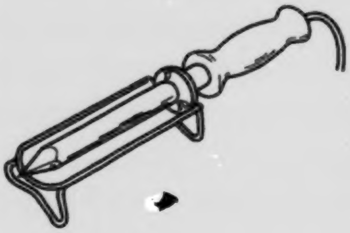
c. ______________________



b. ______________________



d. ______________________



e. ______________________

Objective 3

Match common powered tools with their uses. Some tools may have more than one use. Write the correct numbers in the the blanks.

1. Sabre saw
2. Heat gun
3. Soldering gun
4. Soldering iron
5. Reciprocating saw

_____ a. Cutting holes in wood or plasterboard (tighter areas)

_____ b. Soldering large conductors

_____ c. Drying electronic components and conductors

_____ d. Soldering printed circuit boards

_____ e. Splicing cables

_____ f. Heat shrinking

_____ g. Cutting holes in wood or plasterboard

_____ h. Soldering small heat-sensitive components

Objective 4

List typical powered/specialty equipment below.

a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

Written Test

Objective 5

Select true general safety rules for using power equipment by placing an "X" in the blanks next to the true statements.

_____ a. Follow manufacturer's operating instructions when possible.

_____ b. Never place hands in pinch point.

_____ c. Use eye protection.

_____ d. Wear gloves when working with hot equipment or materials.

_____ e. Always secure loose clothing such as shirt sleeves and shirttails.

_____ f. Exceed rated capacity of equipment if you are behind schedule.

_____ g. Leave running equipment unattended.

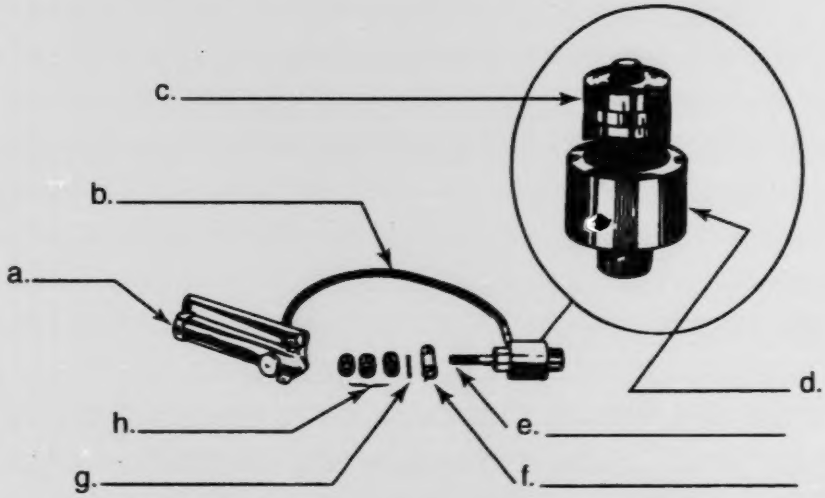
_____ h. Remove protective guards from equipment when they get in the way.

_____ i. Discard electrically powered tools with damaged cords.

_____ j. Unplug electrically powered tools by pulling the cord.

Objective 6

Label the parts of the hydraulic knockout set illustrated below.



Objective 7

Complete the safety rules for using hydraulic knockout sets. Write the word(s) that best completes each statement.

a. Never substitute brake fluid for ______________ ______________.

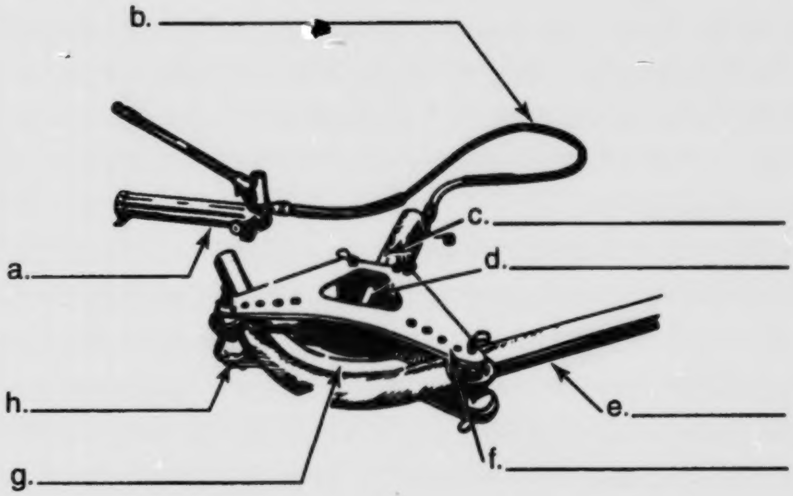
b. Never disconnect hose when it is ______________ ______________.

c. Do not use near __________________________ electrical parts.

d. Never __________________________ pump handle.

Objective 8

Label the parts of the hydraulic pipe bender illustrated below.



Objective 9

Select true safety rules for using hydraulic pipe benders by placing an "X" in the blanks next to the true statements.

_____ a. Substitute brake fluid for hydraulic oil.

_____ b. Never disconnect hose when it is under pressure.

_____ c. Never place hands near ram or shoe while bending.

_____ d. Always use proper size conduit shoe and support

_____ e. Be sure that floor area is clear for pipe movement.

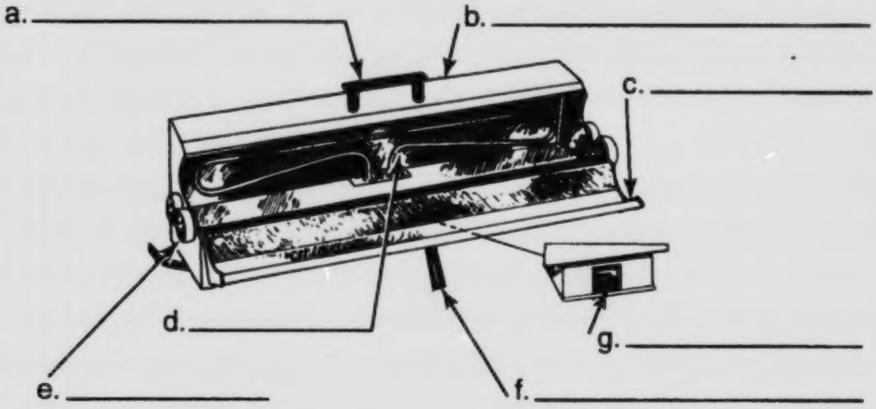
_____ f. Lift heavy bender parts correctly.

_____ g. Make sure that shoe, follow bar, saddle, pipe support, and other accessories are appropriate for the size and type hydraulic pump used.

Written Test

Objective 10

Label the parts of a polyvinylchloride (PVC) heater illustrated below.



Objective 11

Complete safety rules for using electric polyvinylchloride (PVC) heaters and blankets. Circle the word that best completes each rule.

a. Never use in (**dry, wet**) locations.

b. Always wear (**safety shoes, gloves**) when handling hot heater or pipe.

c. Use only with (**PVC, EMT**) conduit.

d. (**Always, Occasionally**) turn bender off when not in use.

e. Use only for specified type and size (**conduit, heating element**)

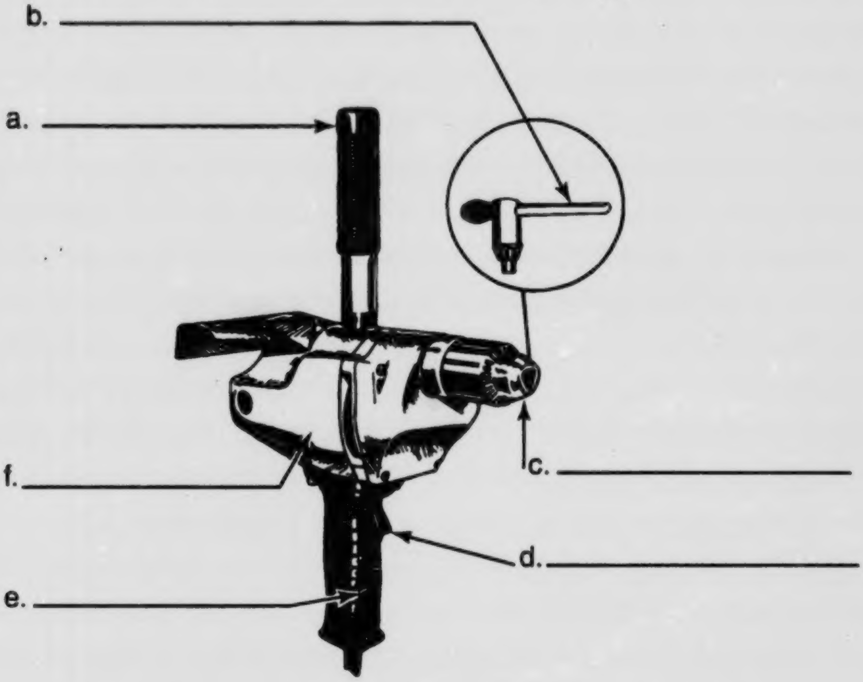
f. Use only in a (**sprinklered, well-ventilated**), noncluttered area.

g. Never leave (**attended, unattended**) while turned on.

h. Keep hands and other body parts from direct contact with (**hot surfaces, electrical cord**).

Objective 12

Label the parts of the power drill illustrated below.



Objective 13

Select true safety rules for using power drills by placing an "X" in the blanks next to the true statements.

_____ a. Always wear gloves.

_____ b. Check area to be drilled for hidden wires or pipes.

_____ c. Hold drill securely with one hand.

_____ d. Never drill while off balance.

_____ e. Place all objects to be drilled in a vise.

_____ f. Always use a T-handle when drilling.

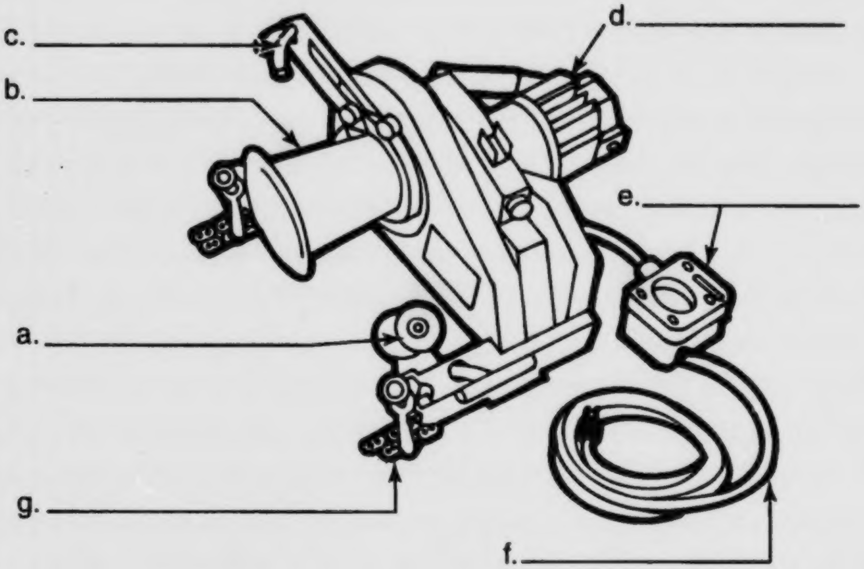
_____ g. **Never** lock the trigger in the "off" position.

_____ h. Always wear eye protection.

Written Test

Objective 14

Label the parts of the hydraulic cable puller illustrated below.



Objective 15

Complete safety rules for using hydraulic cable pullers. Circle the word that best completes each rule.

a. Ensure that all cable pulling systems, accessories, and rope have the proper (**weight, load**) rating for the pull.

b. Mount and secure pulling unit according to (**manufacturer's, *NEC***) instructions.

c. Stand out of direct line of (**work, force**).

d. Monitor pull on (**rope fibers, force gauge**), and never (**exceed, reach**) maximum force.

e. Always wear (**ear, eye**) protection.

Objective 16

Label the parts of the portable and table band saws illustrated below.

Portable Band Saw

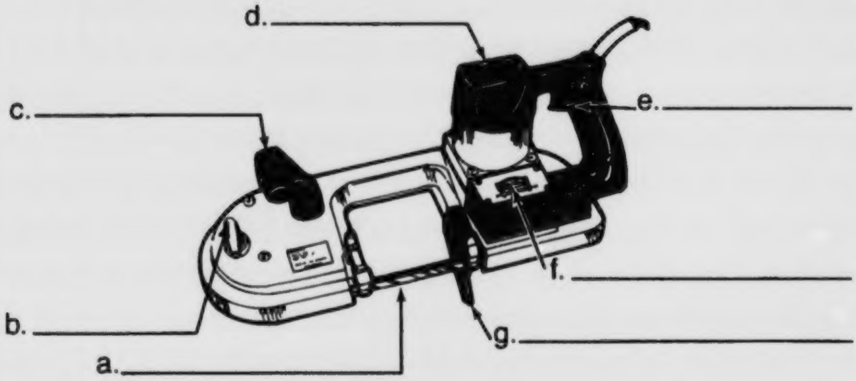
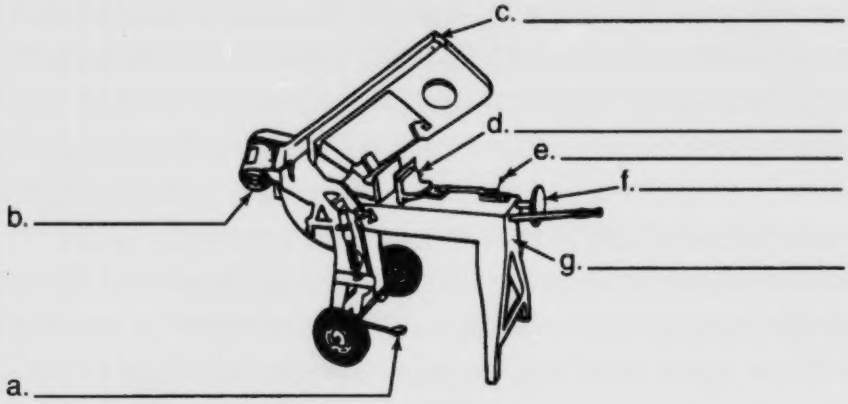


Table Band Saw



Objective 17

Complete safety rules for using portable and table bandsaws.

a. Secure object to be cut in a (**c-clamp, vise**) or other stable rest.

b. Check the blade for missing (**teeth, oil film**) that could result in the blade binding or breaking.

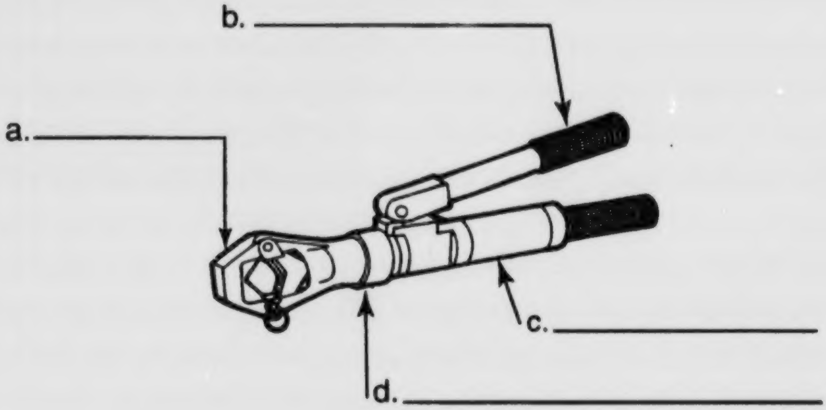
c. Do not remove or alter (**safety guards, saw blade**).

d. Keep (**hands, work**) clear of the blade.

Written Test

Objective 18

Label the parts of the dieless hydraulic crimper illustrated below.



Objective 19

List safety rules for using hydraulic crimpers.

a. ______________________________

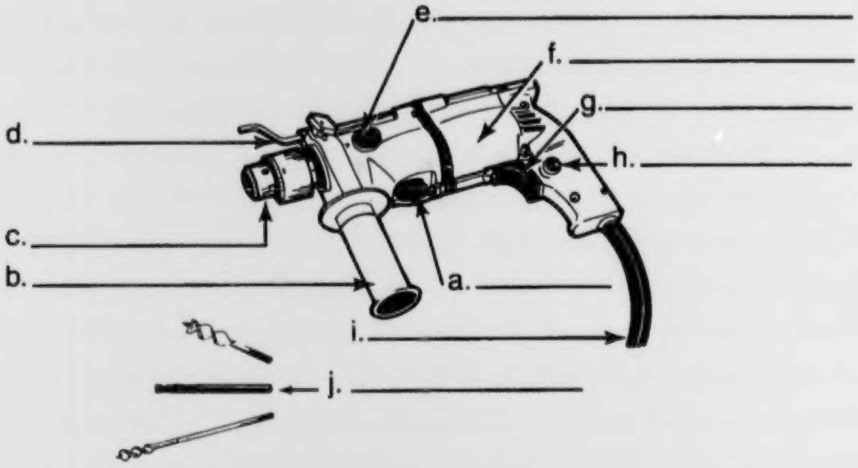
b. ______________________________

c. ______________________________

d. ______________________________

Objective 20

Label the parts of the hammer drill illustrated below.



Objective 21

List safety rules for using hammer drills.

a.

b.

c.

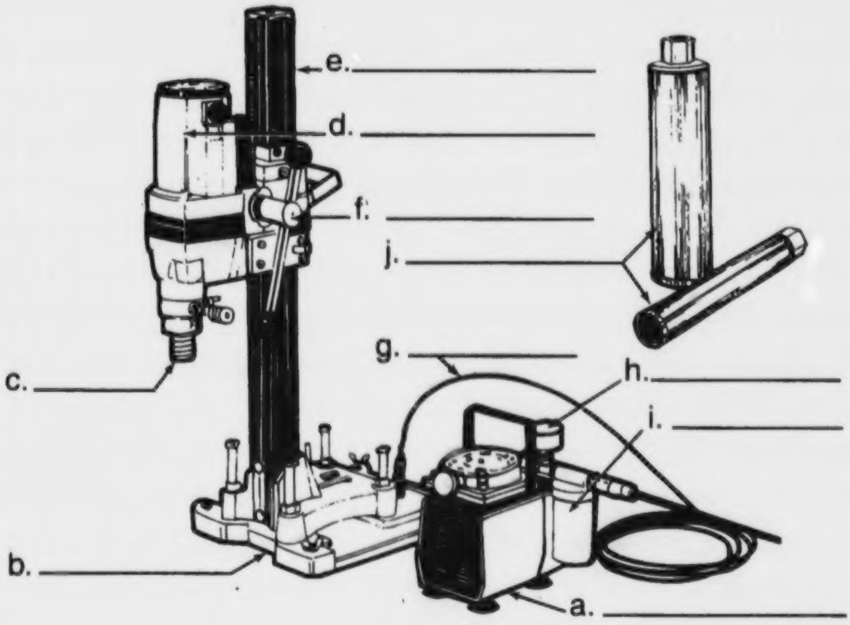
d.

e.

Written Test

Objective 22

Label the parts of the core drilling machine illustrated below.



Objective 23

Complete safety rules for using core drilling machines. Circle the word that best completes each rule.

a. Ensure that the core drilling machine is securely mounted to the (**support table, surface to be drilled**).

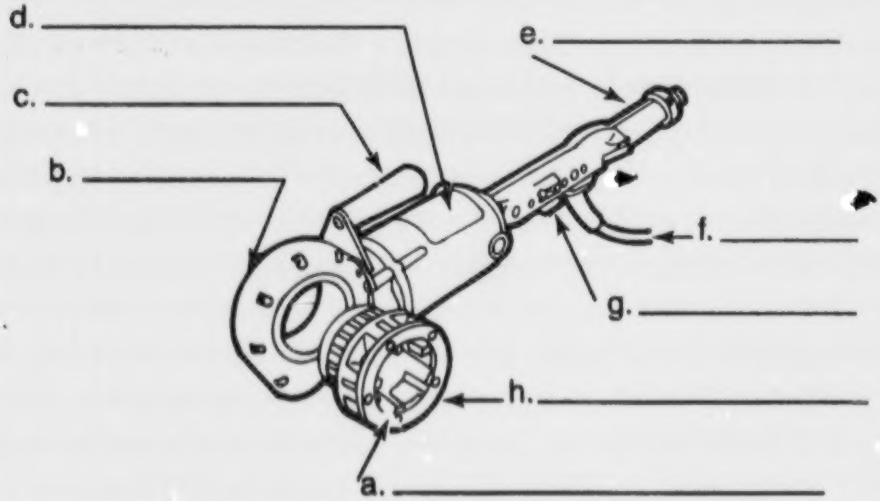
b. Never leave the machine (**mounted, drilling**) while unattended.

c. Do not try to force the drill to cut (**faster, deeper**) than suggested by the manufacturer.

Written Test

Objective 24

Label the parts of the portable power threader illustrated below.



Objective 25

Complete the following statements concerning specific safety rules for using power threaders. Write the word(s) that best completes each statement.

a. Always wear ____________________.

b. Always wear ______________ clothing, tie back ______________

______________, and remove dangling jewelry.

c. Use ____________________ when handling pipe/conduit..

d. Never place ____________________ near turning pipe/conduit.

e. Let threader come to a complete stop before removing pipe/conduit or

____________________ ____________________.

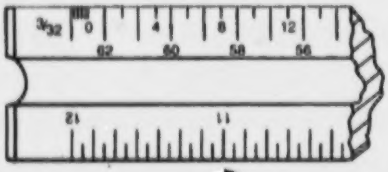
f. Always use a ____________________ to clear thread cuttings.

g. Never operate the threader while ______________ ______________.

Written Test

Objective 26

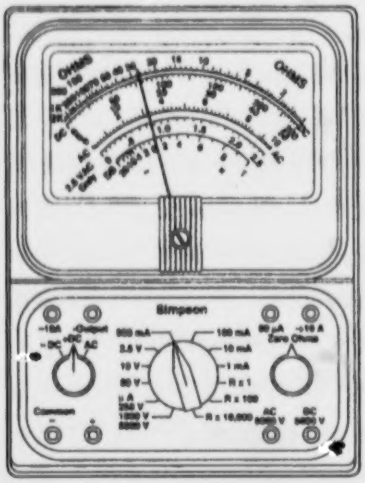
Identify the typical scale illustrated below. Write the correct name below the illustration.

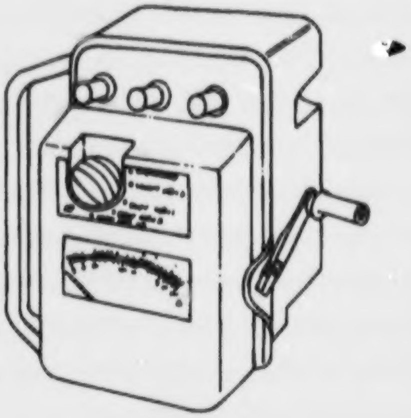

3/32
0
4
8
12
62
60
58
56
12
11

a. ______________________________

Objective 27

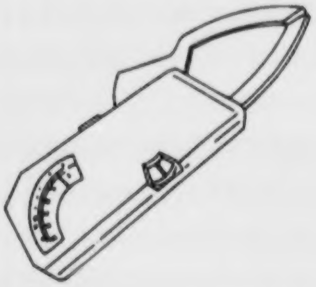
Identify the typical test equipment illustrated below. Write the correct name below each illustration.

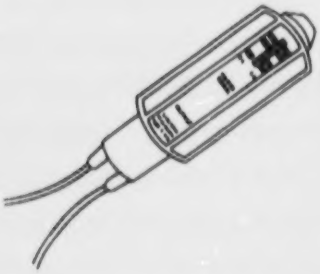

OHMS
OHMS
Simpson
Common
Zero Ohms



a. ______________________________

b. ______________________________





c. ______________________________

d. ______________________________

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 22
b. 20
c. 19
d. 21
e. 18
f. 14
g. 16
h. 10
i. 17
j. 13
k. 8
l. 9
m. 5
n. 3
o. 2
p. 1
q. 6
r. 7
s. 4
t. 11
u. 12
v. 15

Objective 2

a. Reciprocating saw
b. Soldering gun
c. Heat gun
d. Sabre saw
e. Soldering iron

Objective 3

a. 5
b. 3
c. 2
d. 4
e. 3
f. 2
g. 1
h. 4

Objective 4

a. Hydraulic knockout
b. Hydraulic bender
c. Electric PVC heater
d. Power drill
e. Power threader

Objective 5

b, c, d, e

Objective 6

a. Hydraulic pump
b. Hydraulic hose
c. Knockout cutter
d. Die
e. Hydraulic threaded ram
f. Screw sleeve
g. 1/2-inch knockout adapter
h. Spacers

Objective 7

a. Hydraulic oil
b. Under pressure
c. Live
d. Force

Answers to Written Test

Objective 8	a.	Hydraulic pump
	b.	Hydraulic hose
	c.	Ram travel gauge
	d.	Hydraulic ram
	e.	Pipe
	f.	Bender frame
	g.	Bender shoe
	h.	Pipe support
Objective 9	b, c, d, e, g	
Objective 10	a.	Carrying handle
	b.	Heater outer case
	c.	Door
	d.	Heating element
	e.	Pipe rollers
	f.	Insulated door handle
	g.	On/off switch
Objective 11	a.	Wet
	b.	Gloves
	c.	PVC
	d.	Always
	e.	Conduit
	f.	Well-ventilated
	g.	Unattended
	h.	Hot surfaces
Objective 12	a.	Cross handle
	b.	Chuck key
	c.	Chuck
	d.	Power trigger
	e.	Reverse/forward switch
	f.	Drill motor
Objective 13	b, d, f, h	
Objective 14	a.	Right-angle sheave
	b.	Tapered capstan
	c.	Rope guide
	d.	Motor
	e.	Force gauge
	f.	Power cord
	g.	Mounting chains
Objective 15	a.	Load
	b.	Manufacturer's
	c.	Force
	d.	Exceed
	e.	Eye

Answers to Written Test

Objective 16

Portable Band Saw

a. Blade band
b. Blade tension adjustment lever
c. Forward handle grip
d. Motor
e. Handle grip on/off trigger
f. Blade angle adjustment
g. Stock stop

Table Band Saw

a. Table foot brake
b. Motor
c. Band saw
d. Adjustable keeper
e. On/off switch
f. Keeper adjustment handle
g. Work table

Objective 17

a. Vise
b. Teeth
c. Safety guards
d. Hands

Objective 18

a. Dieless, hinged crimping head
b. Hydraulic pump handle
c. Hydraulic pump
d. Swivel

Objective 19

a. Ensure that die is mounted securely on threading machine.
b. Keep die flooded with cutting oil during operation.
c. Keep hands, clothing, and hair away from rotating parts.
d. Always wear eye protection.

Objective 20

a. Variable speed switch
b. T-handle front grip
c. Chuck
d. Depth gauge
e. Hammer selector
f. Motor
g. On/off trigger
h. Reverse button
i. Power cord
j. Masonry and steel drill bits

Answers to Written Test

Objective 21

a. Always hold the drill steady and perpendicular to the work to prevent the bit from breaking or binding.
b. Always use a T-handle when drilling to allow you to secure the hammer drill when it encounters especially hard surfaces.
c. Never lock the trigger in the "on" position.
d. Never drill while off balance.
e. Always wear eye protection.

Objective 22

a. Vacuum pump
b. Anchor base
c. Spindle shaft for bit
d. Drill motor
e. Mast
f. Motor height adjustment handle
g. Air hose
h. Pressure gauge
i. Air filter/dryer
j. Core bits

Objective 23

a. Surface to be drilled
b. Drilling
c. Faster

Objective 24

a. Pipe chuck
b. Threader head
c. Forward handle grip
d. Motor
e. Handle
f. Power cord
g. Pressure on/off switch
h. Die

Objective 25

a. Eye protection
b. Tight-fitting, long hair
c. Gloves
d. Hands
e. Reversing direction
f. Brush
g. Off balance

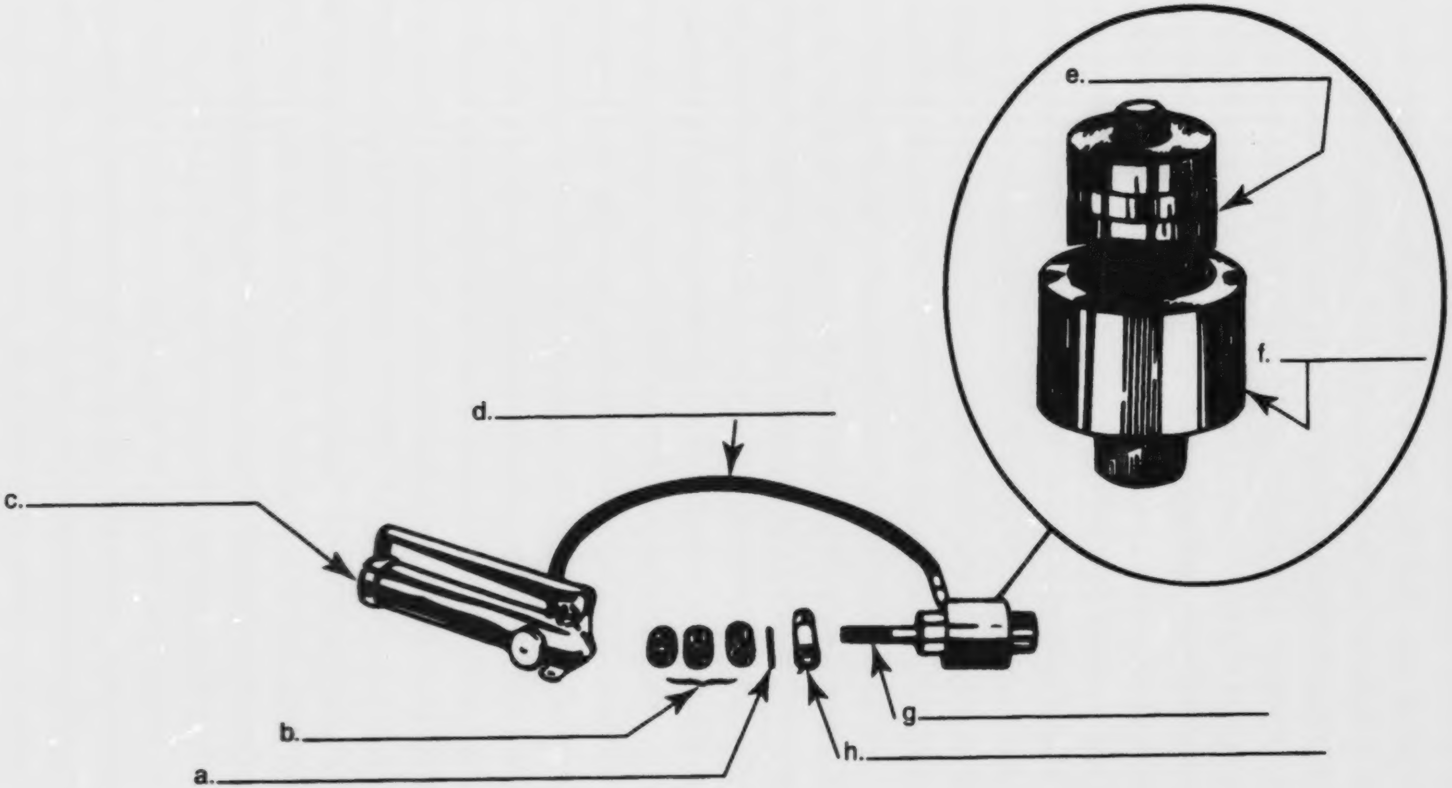
Objective 26

a. Architect's scale

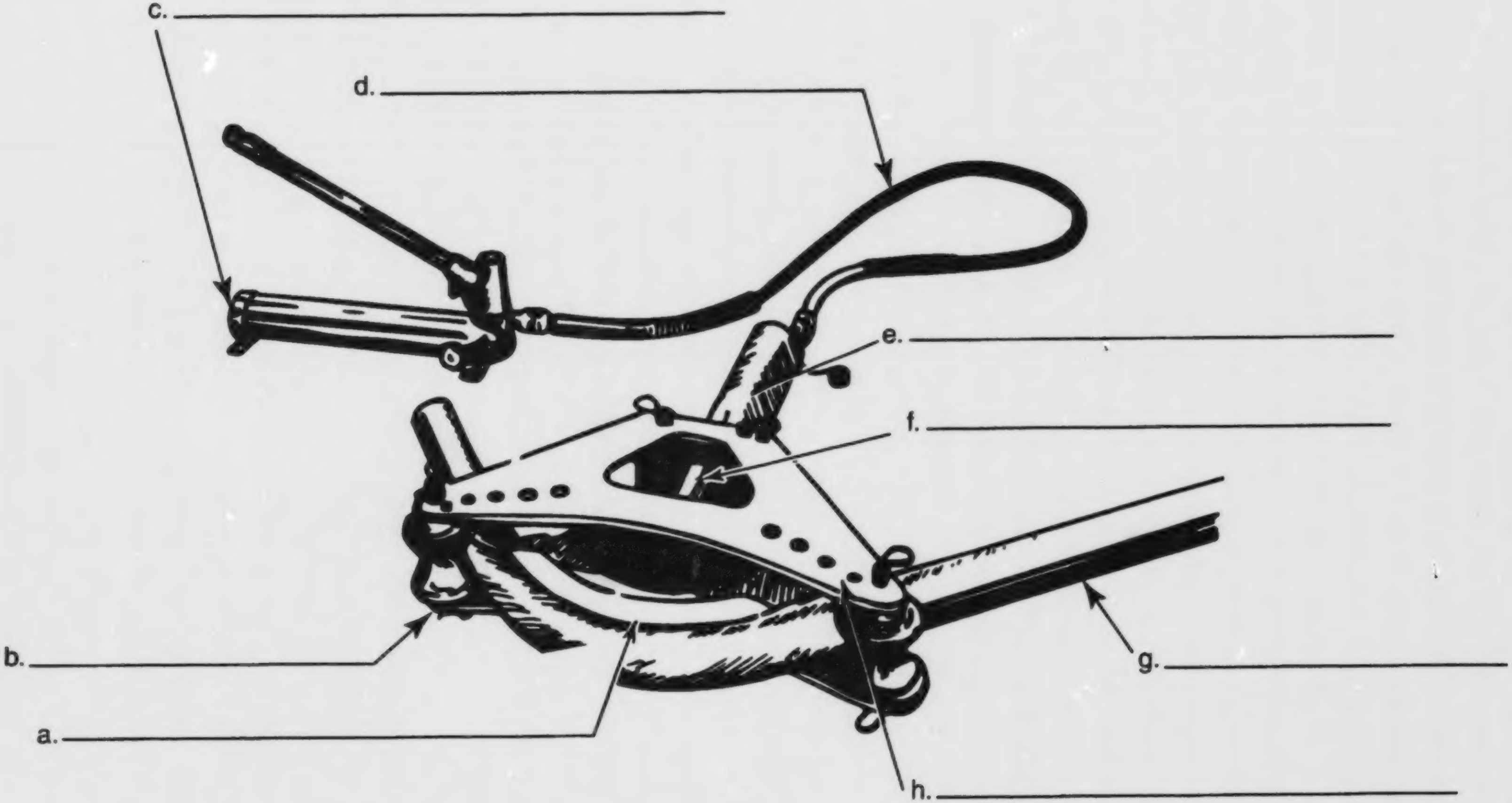
Objective 27

a. Voltage tester
b. Multimeter (VOM)
c. Clamp-on ammeter
d. Megometer (megger)

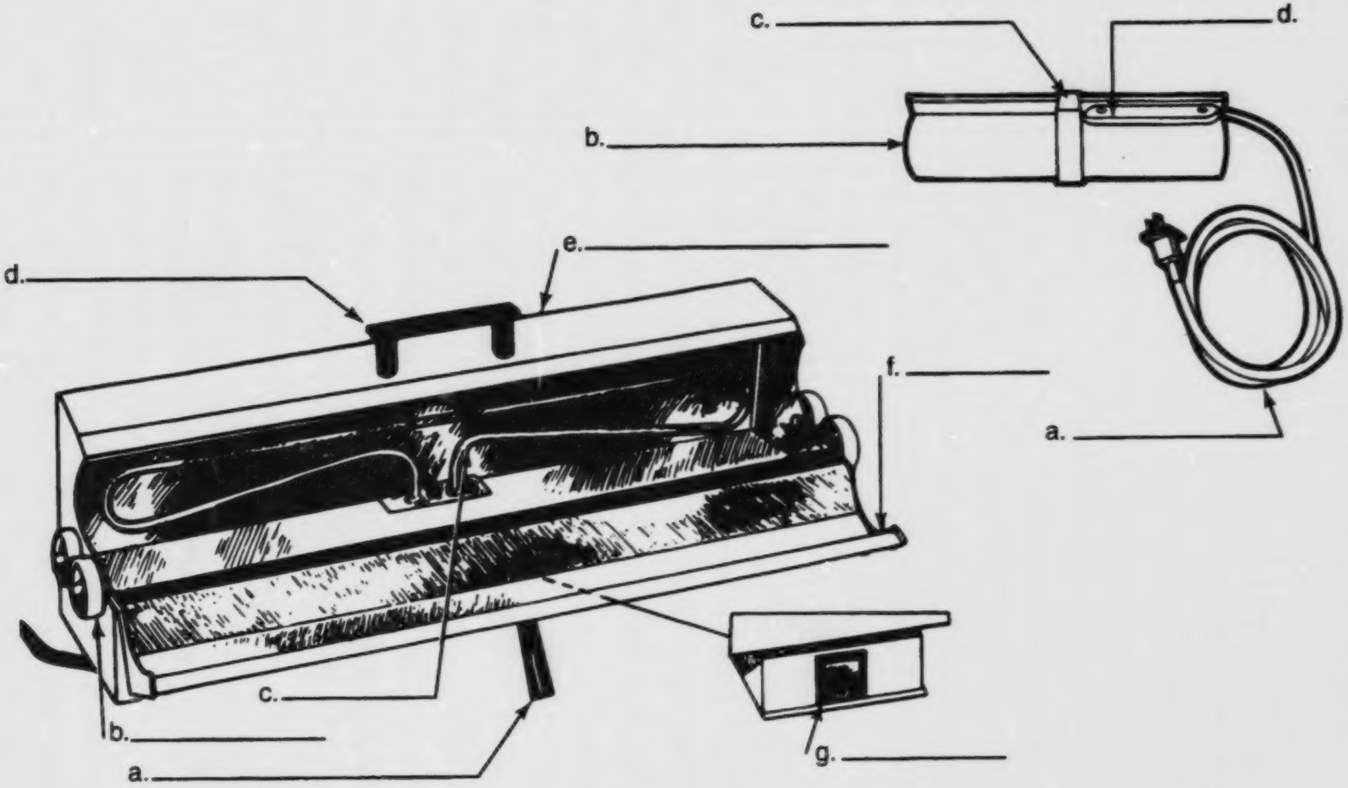
Hydraulic Knockout Set



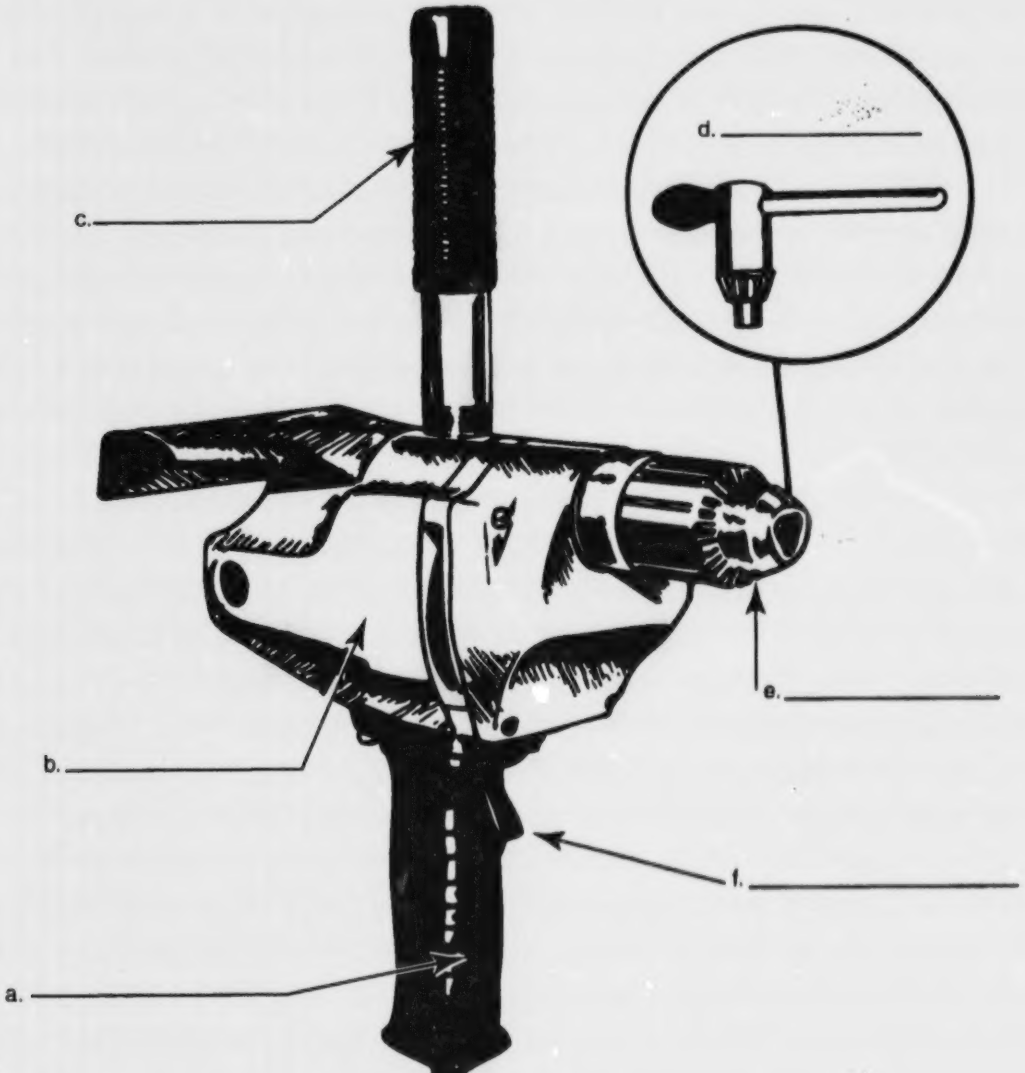
Hydraulic Pipe Bender



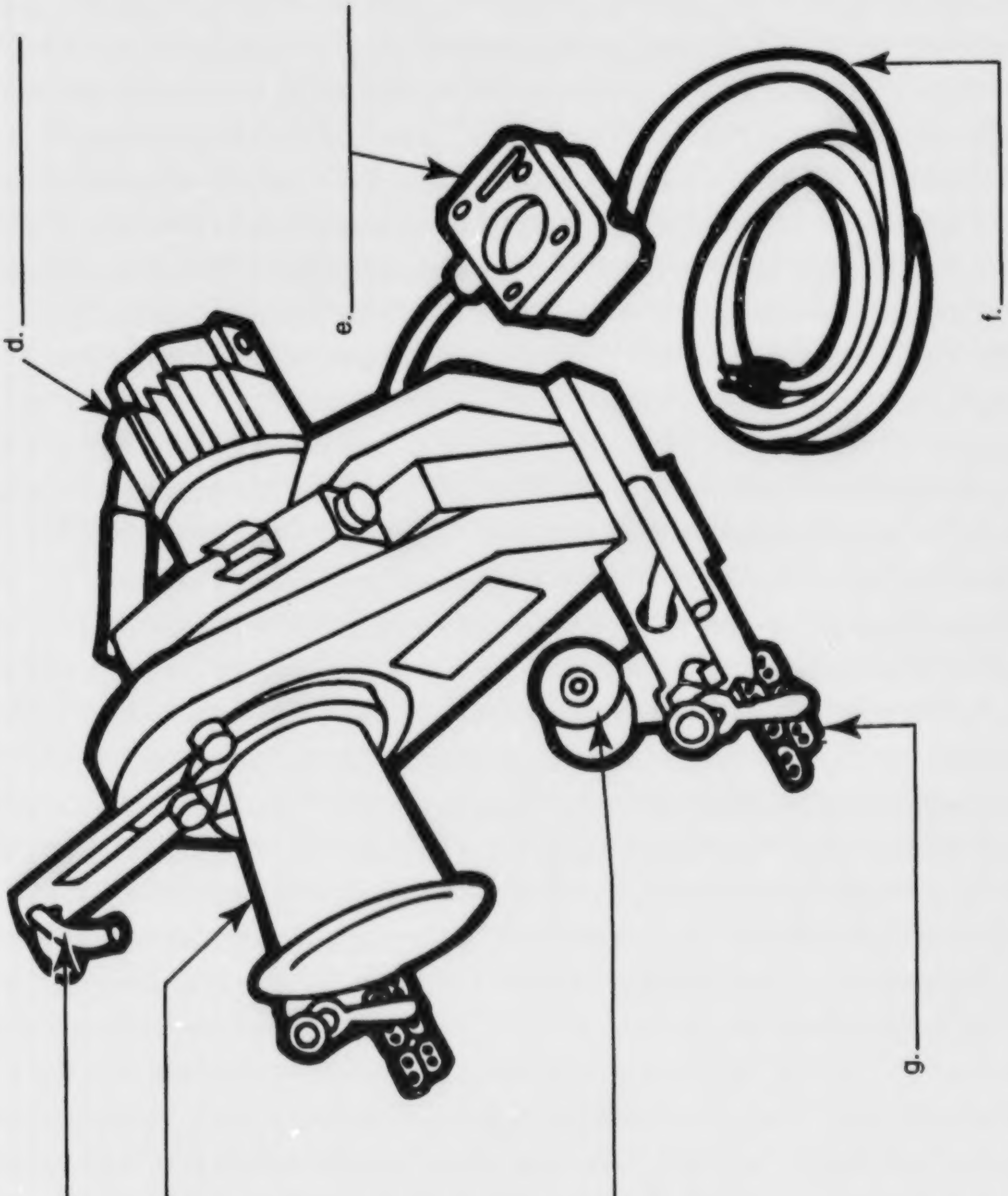
PVC Heater and Blanket


c.
d.
b.
a.
e.
d.
f.
c.
b.
a.
g.

Power Drill



Power Cable Puller



Portable and Table Band Saws

Portable Band Saw

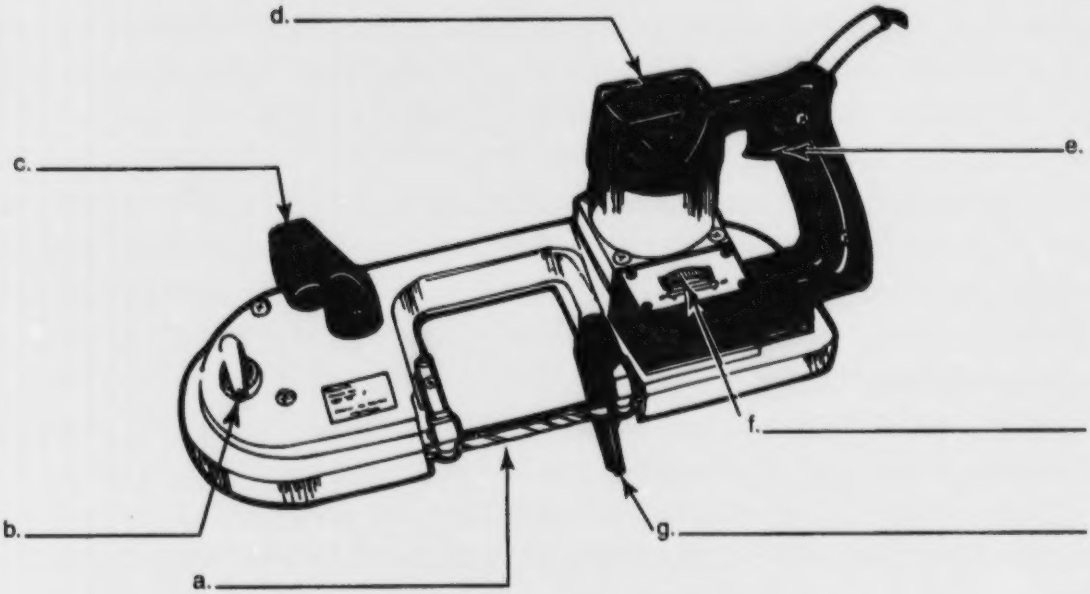
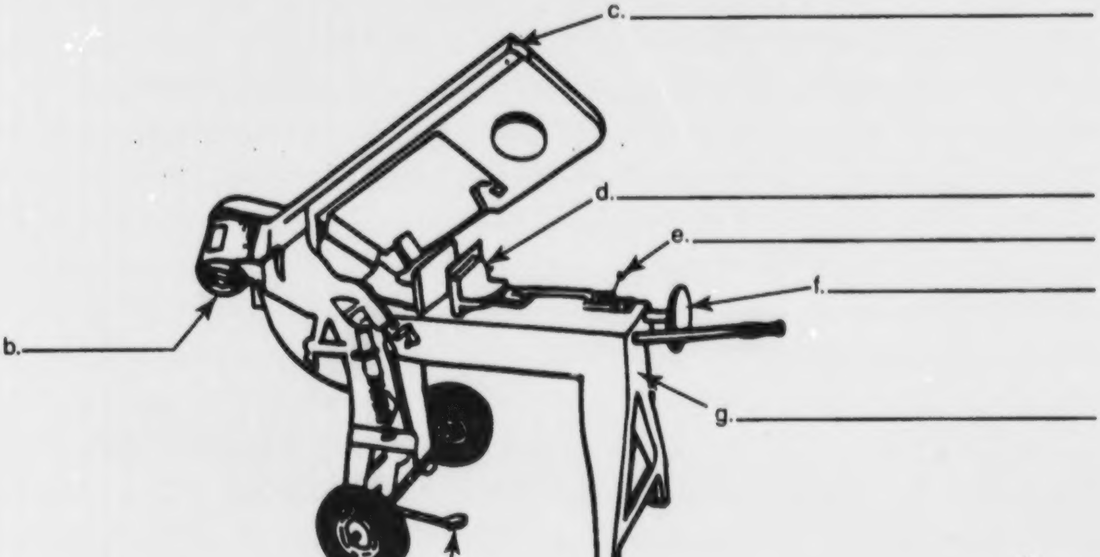
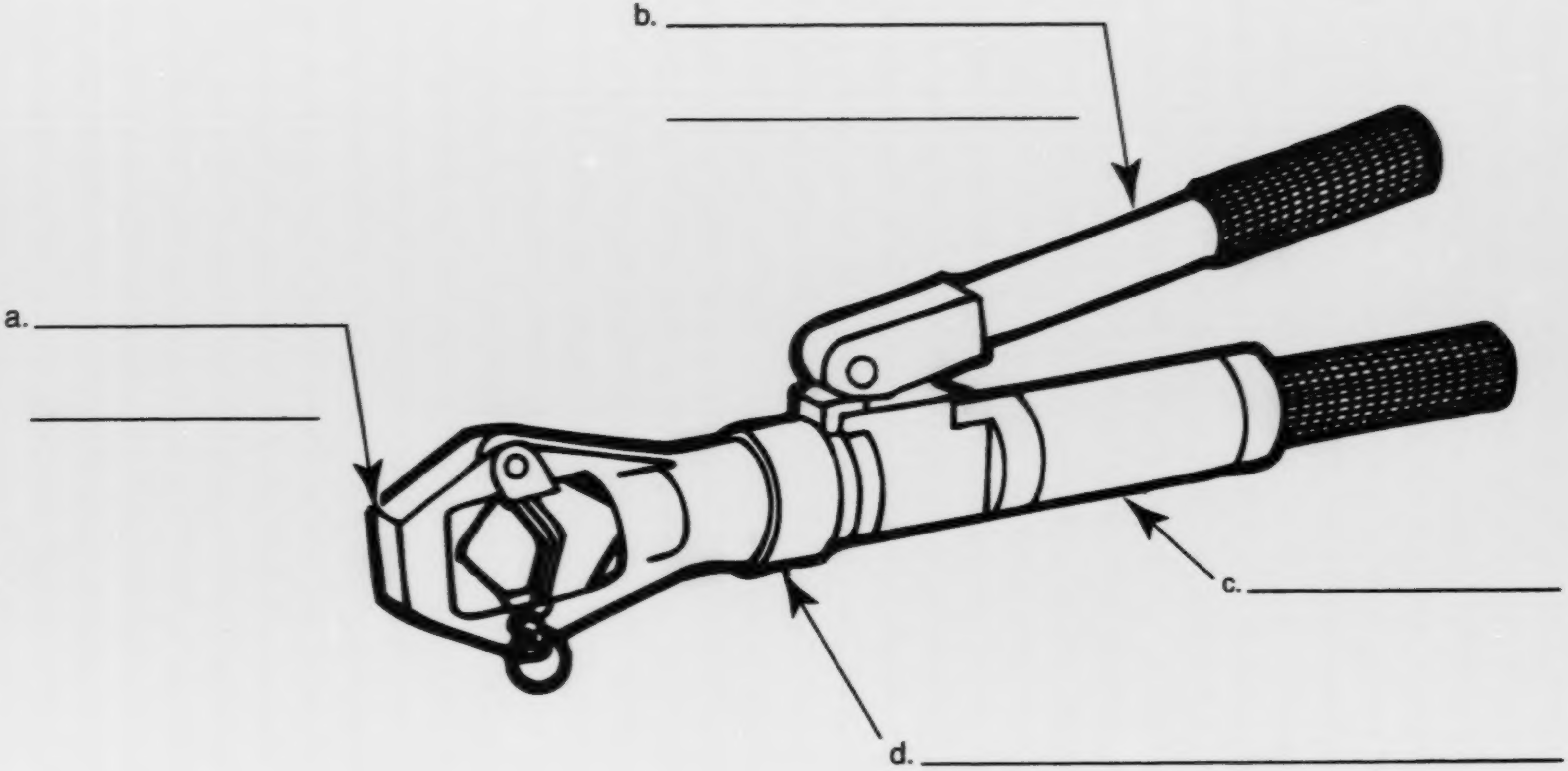


Table Band Saw

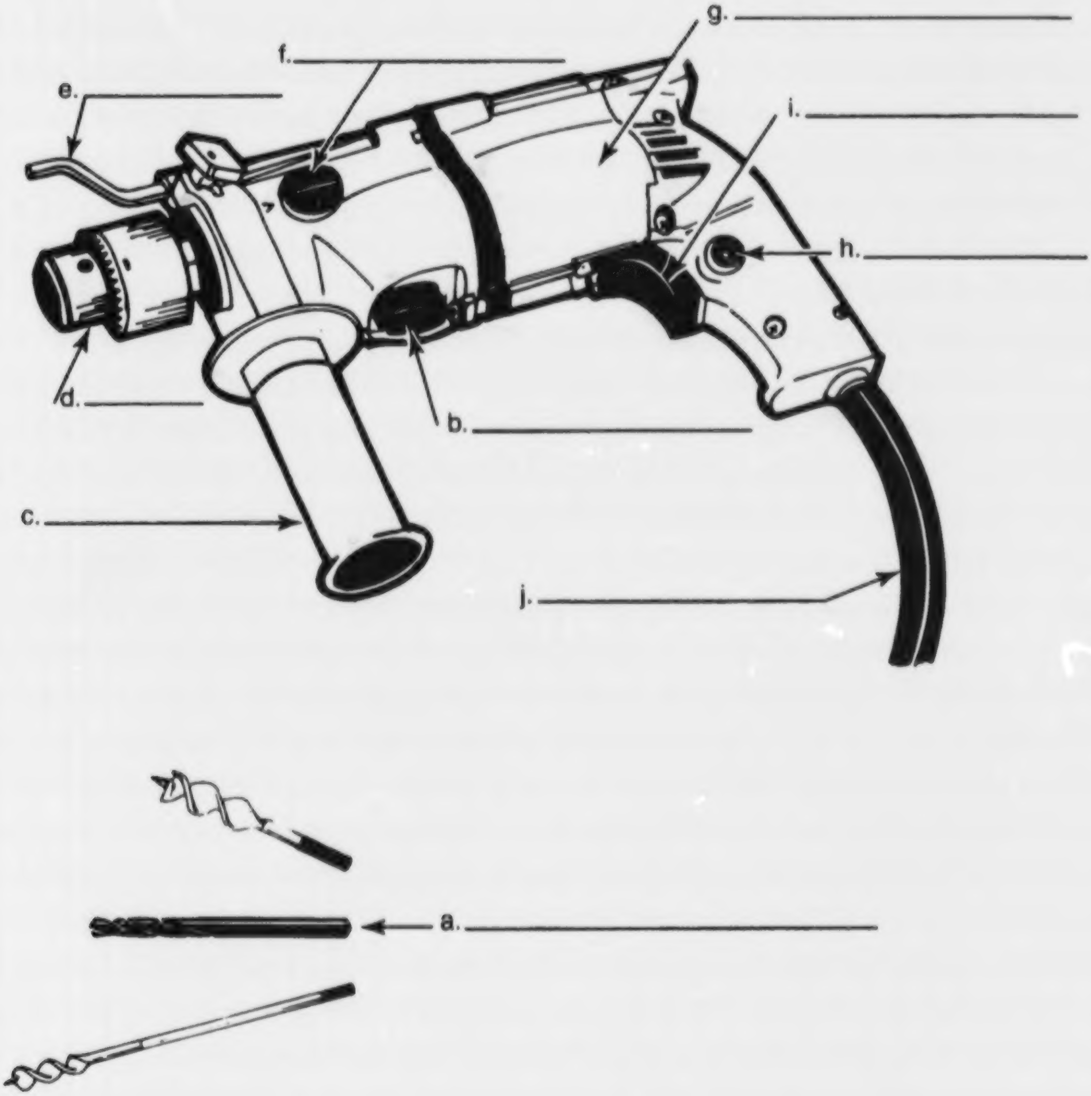


TM 6

Dieless Hydraulic Crimper

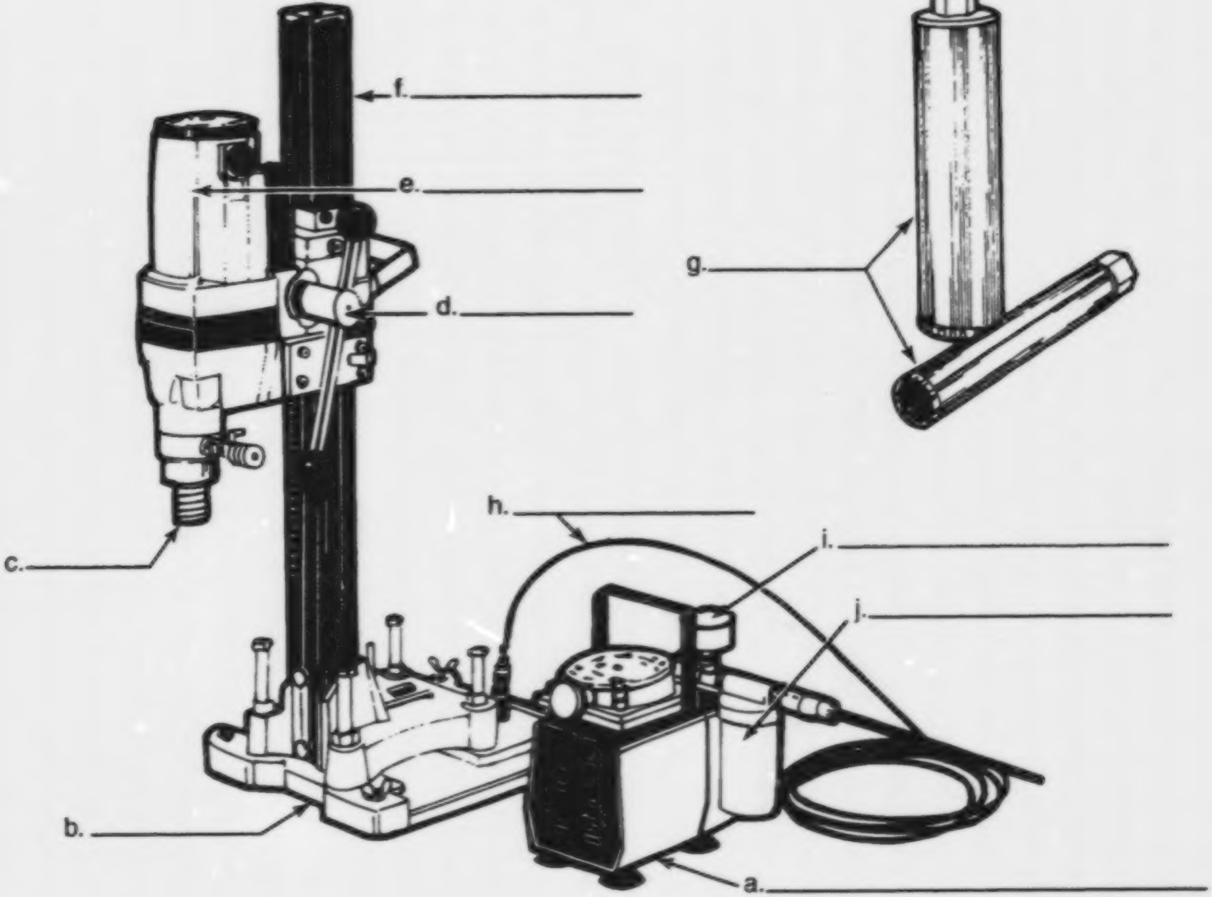


Hammer Drill

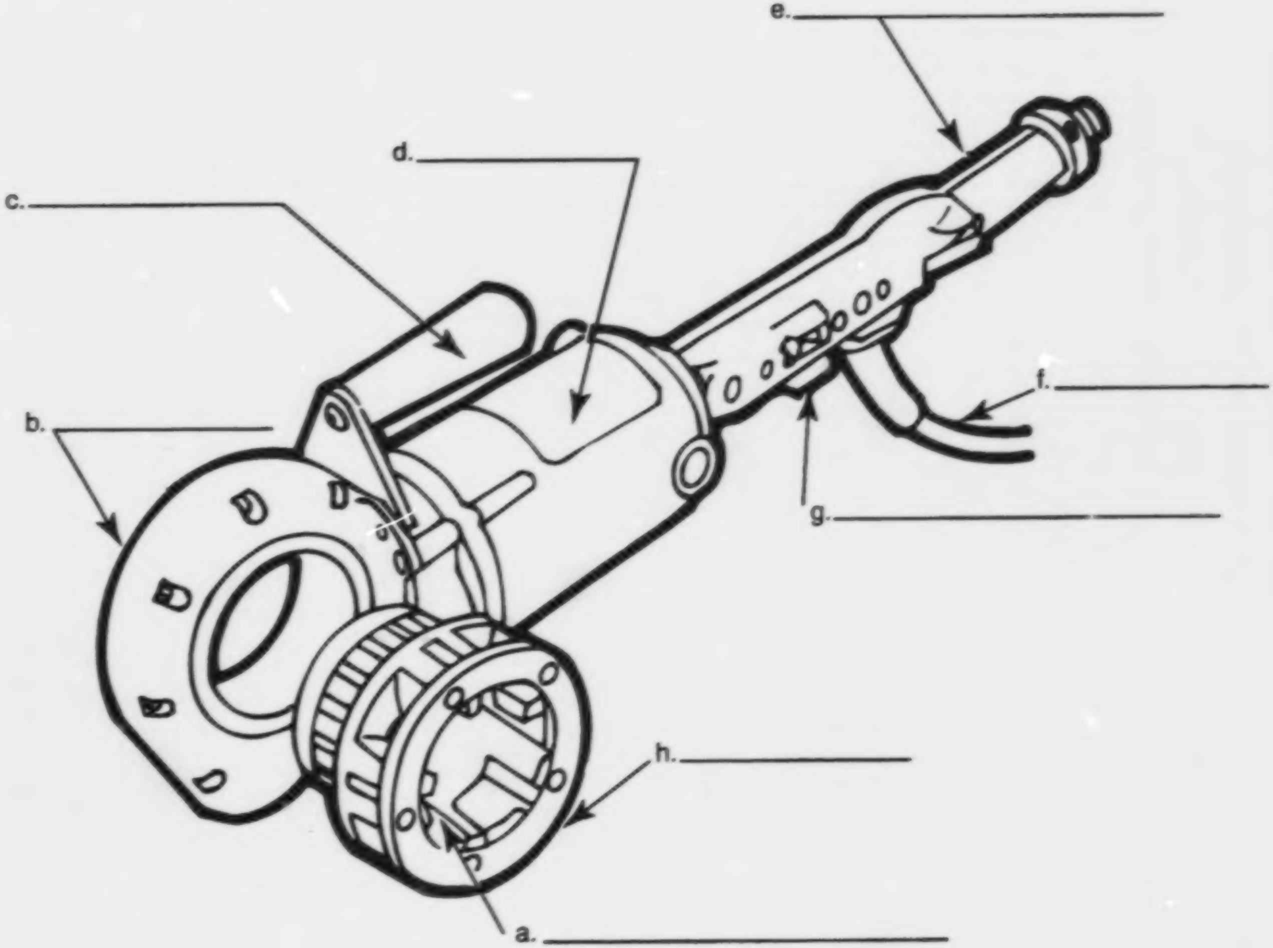

g.
f.
e.
i.
h.
d.
b.
c.
j.
a.

TM 8

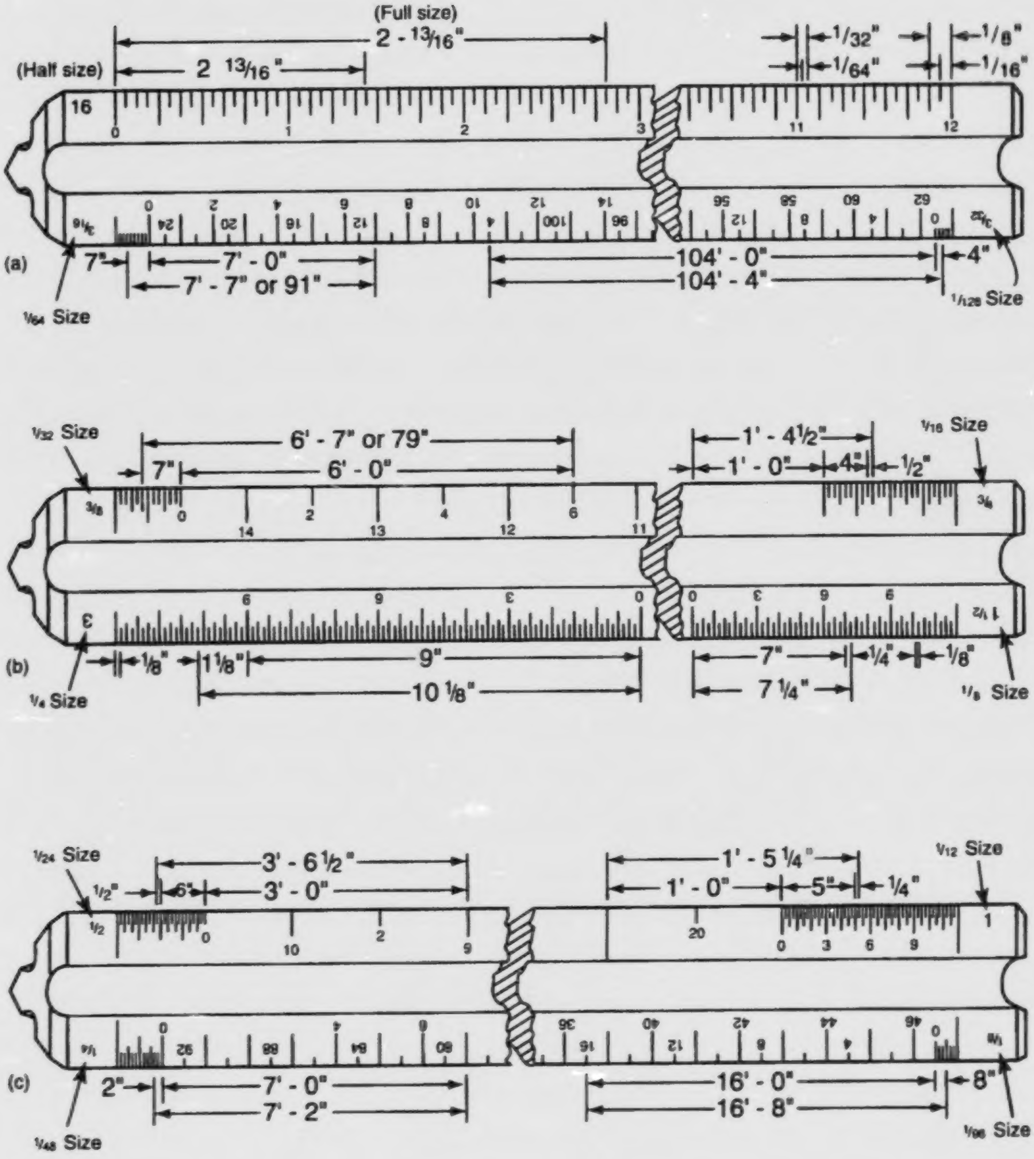
Core Drilling Machine


f.
e.
d.
c.
g.
h.
i.
j.
b.
a.

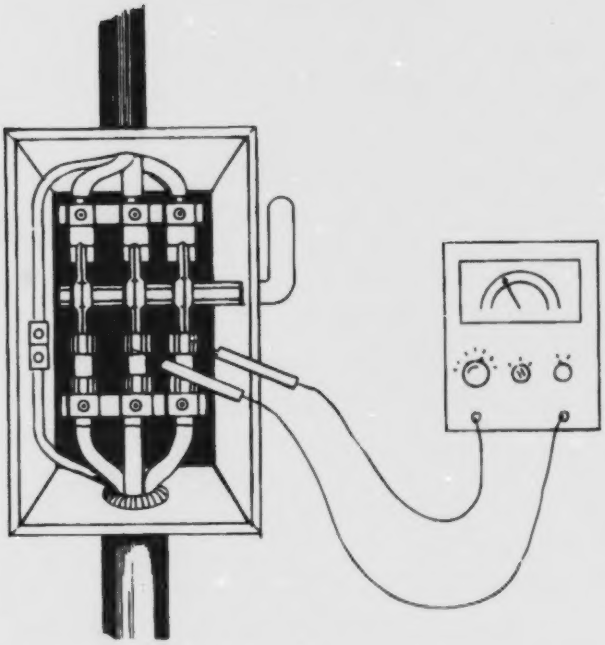
Portable Power Threader



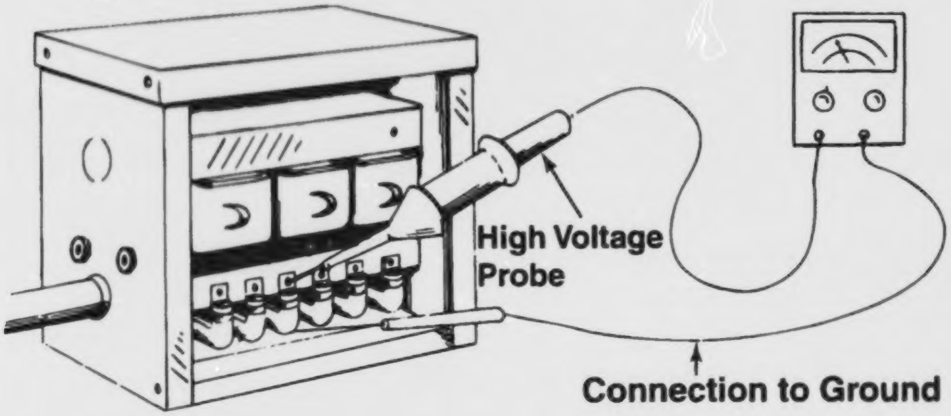
Architect's Scale


(Full size)
2 - 13/16"
(Half size)
2 13/16"
1/32"
1/8"
1/64"
1/16"
16
3/16
3/32
(a)
7"
7' - 0"
7' - 7" or 91"
104' - 0"
104' - 4"
4"
1/64 Size
1/128 Size
1/32 Size
6' - 7" or 79"
7"
6' - 0"
1' - 4 1/2"
1' - 0"
4"
1/2"
1/16 Size
3/8
3/4
3
1 1/2
(b)
1/8"
1 1/8"
9"
10 1/8"
7"
1/4"
1/8"
7 1/4"
1/4 Size
1/8 Size
1/24 Size
3' - 6 1/2"
1/2"
6"
3' - 0"
1' - 5 1/4"
1' - 0"
5"
1/4"
1/12 Size
1/2
1
1/4
1/8
(c)
2"
7' - 0"
7' - 2"
16' - 0"
8"
16' - 8"
1/48 Size
1/96 Size

Voltage Measurement Techniques

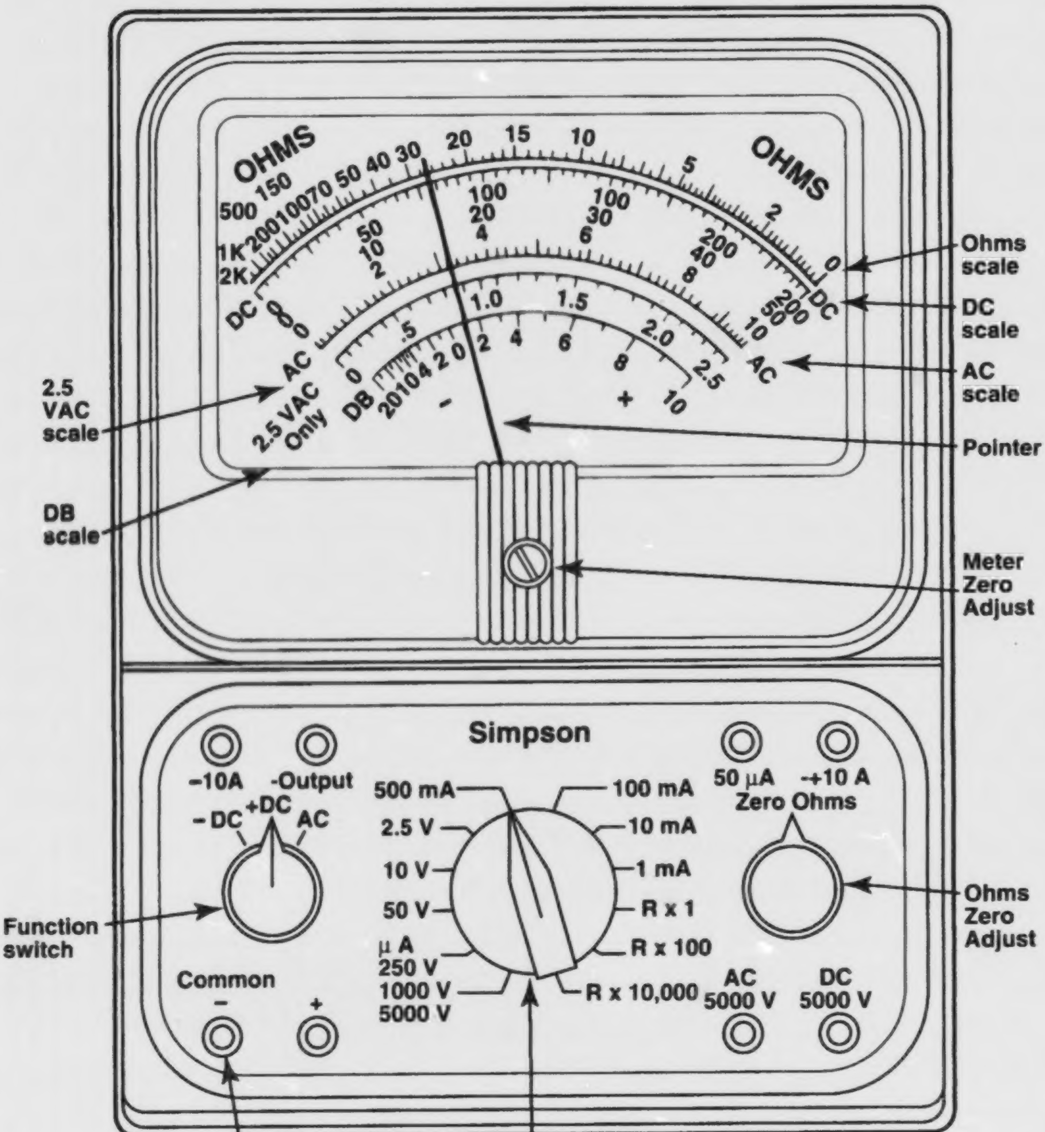


Direct Parallel Measurement

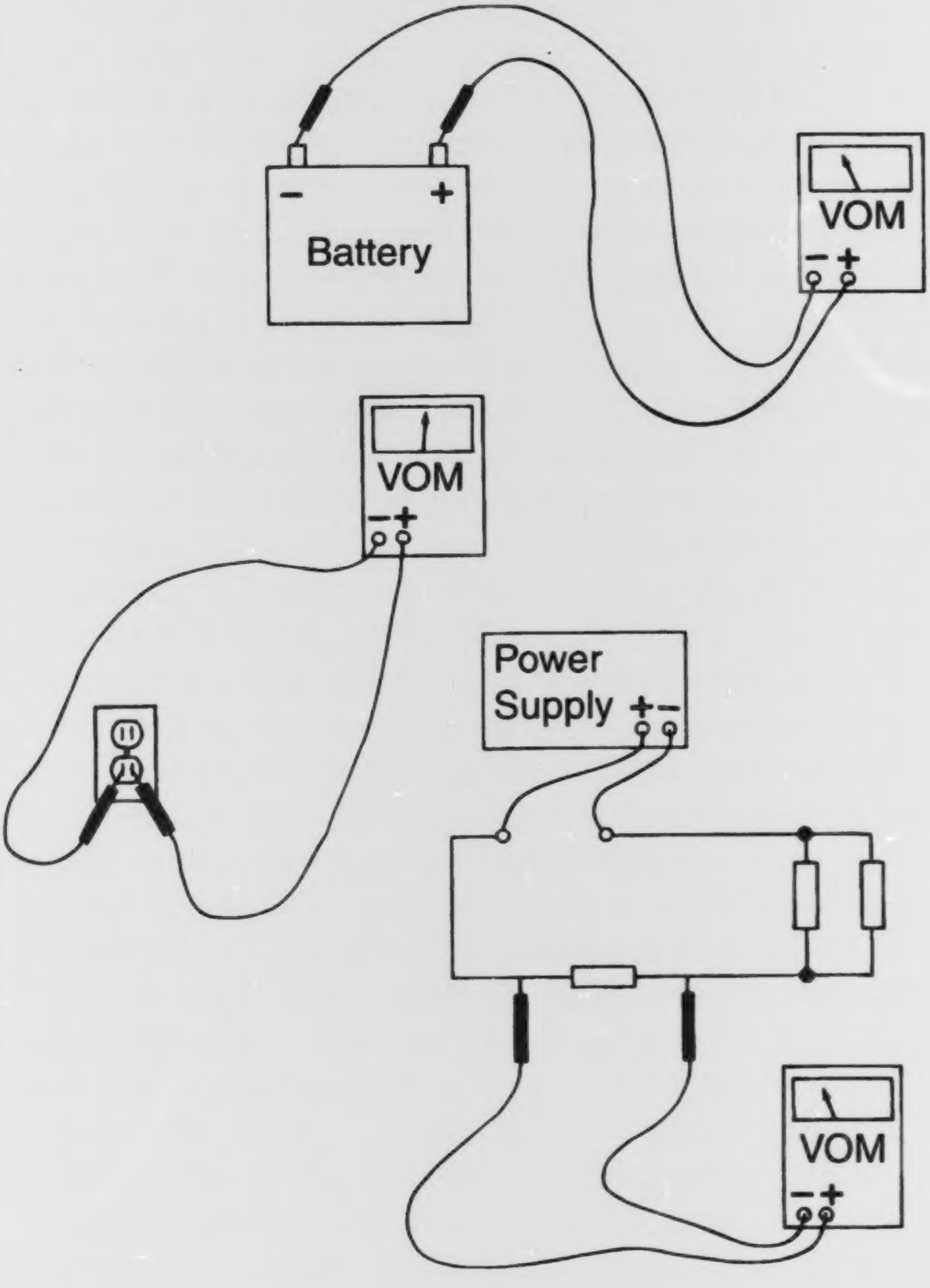

High Voltage Probe
Connection to Ground

High Voltage Probe

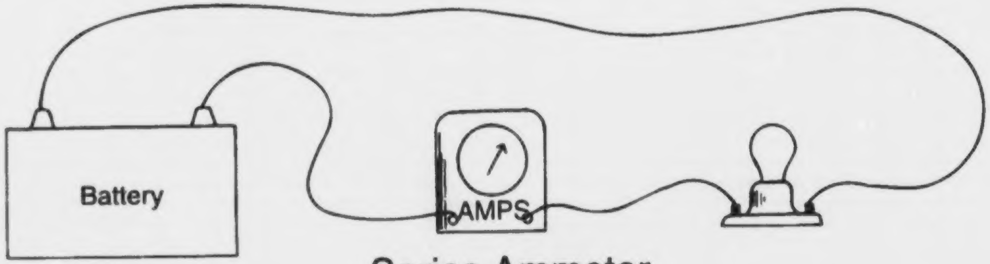
Permanent Magnet Moving Coil Multimeter


OHMS
OHMS
500 150
1K 200 100 70 50 40 30 20 15 10 5 2 0
2K
100 20 4
100 30 6
200 40 8
200 50 10
50 10 2
DC 0 0 0
DC
AC 0 .5 1.0 1.5 2.0 2.5
AC
DB 20 10 4 2 0 2 4 6 8 10
- +
2.5 VAC Only
Ohms scale
DC scale
AC scale
Pointer
2.5 VAC scale
DB scale
Meter Zero Adjust
Simpson
-10A
-Output
- DC
+DC
AC
Function switch
Common
-
+
500 mA
2.5 V
10 V
50 V
μ A 250 V
1000 V 5000 V
100 mA
10 mA
1 mA
R x 1
R x 100
R x 10,000
50 μA
-+10 A
Zero Ohms
Ohms Zero Adjust
AC 5000 V
DC 5000 V
Test jack
Range switch

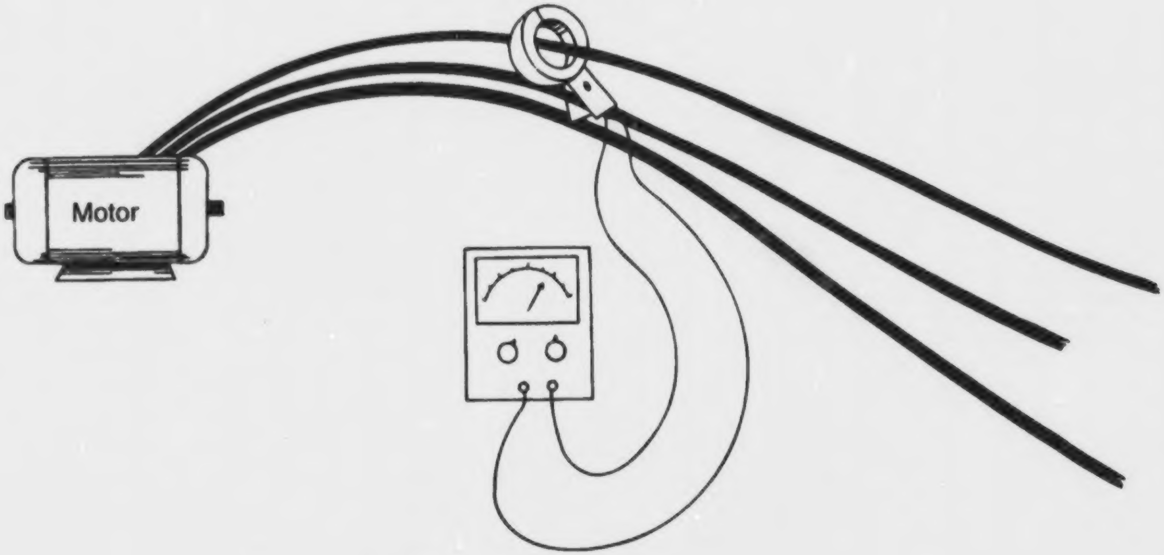
Correct Voltage Measurements


–
+
Battery
VOM
– +
VOM
– +
Power
Supply + –
VOM
– +

Amperage Measurement Techniques


Battery
AMPS

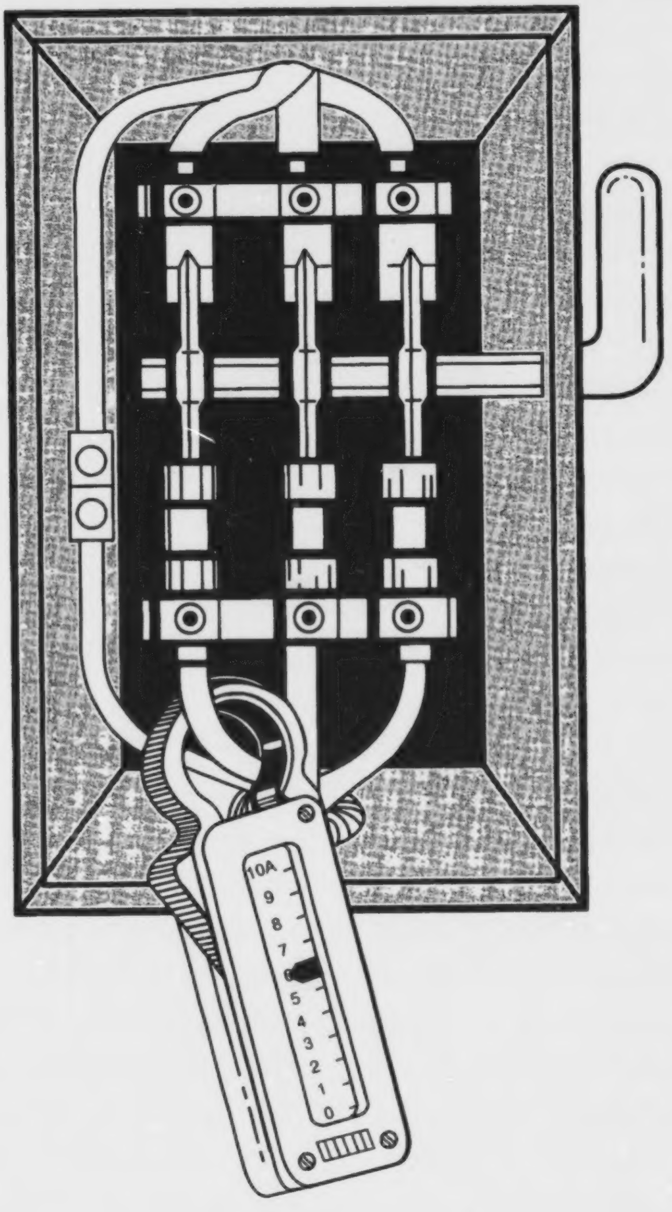
Series Ammeter



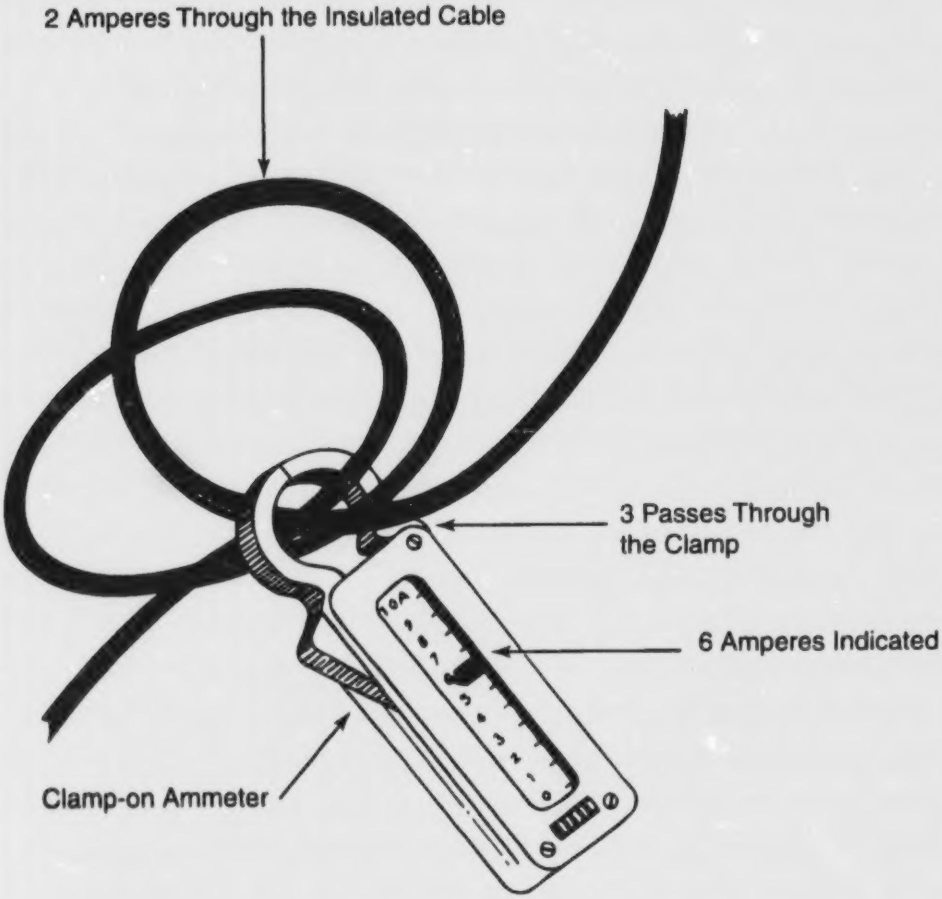
Clamp-on Probe

Clamp-on Ammeter

Measuring Current in a Safety Switch Using a Clamp-on Ammeter


10A
9
8
7
6
5
4
3
2
1
0

Determining Current of a Multiple Loop Using a Clamp-on Ammeter


2 Amperes Through the Insulated Cable
3 Passes Through the Clamp
6 Amperes Indicated
Clamp-on Ammeter
10A
9
8
7
6
5
4
3
2
1
0

Note: The loops should be wrapped tightly together with electrical tape at the point of measurement.

TM 17

Unit 7 Using Trade Information

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 7–3
Answers to Assignment Sheets 7–9
Written Test 7–13
Answers to Written Test 7–17

Student Components

Student Page

Learning Activities Sheet 7–3
Objective Sheet 7–5
Information Sheet 7–7

* Focus Assignment

Using the *National Electrical Code* 163

* Assignment Sheets

1—Use the *National Electrical Code* index to answer questions about *Code* sections 165
2—Use the *National Electrical Code* title page, table of contents, and introduction to answer questions 167
3—Use the *National Electrical Code* first chapter to define terms 169
4—Use the *National Electrical Code* to answer general questions related to residential wiring 173
5—Use the *National Electrical Code* to locate allowable ampacities for various conductors 175
6—Use the *National Electrical Code* to interpret conduit fill tables 177
7—Find information in the *National Electrical Code* 181

* Focus Assignment and Assignment Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Prepare activity sheets covering service drop clearance, sizing grounded conductors, and working clearances for use as a group activity in finding and interpreting the appropriate codes.

  Note: A good source for activity is the *NEC Handbook 1999*. See Suggested Supplemental Resources section that follows.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Provide students with a copy of the *National Electrical Code*, and stress its purpose and importance.

- Invite a local inspector to speak to the class.

- Provide students with copies of local electrical codes.

- Have students complete Assignment Sheet 6 using metric calculations. (Answer sheet for Assignment Sheet 6 also contains the answers in their metric equivalent).

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Early, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993.* Quincy, MA: National Fire Protection Association, 1992.
- *National Electrical Code, 2002.* Quincy MA: National Fire Protection Association, 2001.
- Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Activities

- Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Department of Vocational-Technical Education/Curriculum and Instructional Materials Center, 1984.
- *National Electrical Code*, 1999. Quincy, MA: National Fire Protection Association, 1998.

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes*. Quincy MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC.

- *NEC 2002 Handbook*. Quincy MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics.

  The publications listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org

- Miller, Chris. *Illustrated Guide to the National Electrical Code*, 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type of occupancy, and contains 600 illustrations.

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code*, 6th ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied.

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers*, 2nd ed. Delmar Publishers, Inc. 2002.

Electronic Media

NEC Video Set (set of four)

- Video 1: Familiarizes viewers with the mission of the National Fire Protection Association, introducing the role of Code-making panels, and explains the three-year Code publication cycle
- Video 2: Gives viewers practical insight into the way words are used throughout the NEC. Articles 80, 90, 100, and 110 are the main focus
- Video 3: Shows viewers how to use the table of contents to navigate quickly and efficiently through the Code
- Video 4: Provides specific tools for locating, understanding, and interpreting Code rules

Available on video or CD-ROM, this set can be purchased online at www.delmar.com or by calling 1-800-477-3692

Answers to Assignment Sheets

Assignment Sheet 1

Use the *National Electrical Code* index to answer questions about *Code* sections

a. 513
b. 250.102
c. 314V
d. 368.5
e. 410.8
f. 410.66
g. 408.16
h. 551.30
i. 430.82(C)
j. 517.78, 660IV

Assignment Sheet 2

Use the *National Electrical Code* title page, table of contents, and introduction to answer questions

a. Safeguarding; 90.1(A)
b. 9; 90.3
c. Chapter 9; 90.3
d. Vertical
e. Mandatory rules; 90.5(A)
f. Informational; 90.5(C)

Assignment Sheet 3

Use the *National Electrical Code* first chapter to define terms

a. *Code* Section 100 I

1. "The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating"

2. "The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s)"

3. "A point on the wiring system at which current is taken to supply utilization equipment"

4. "Service conductors made up in the form of a cable"

5. "The permanent joining of metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to conduct safely any current likely to be imposed"

6. "A conductor encased within material of composition or thickness that is not recognized by this *Code* as electrical insulation"

7. "A contact device installed at the outlet for the connection of an attachment plug"

8. "The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure"

9. "A unit of an electrical system that is intended to carry but not utilize electric energy"

10. "A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply"

11. "A general term including material, fittings, devices, appliances, luminaires (fixtures), apparatus, and the like used as part of, or in connection with, an electrical installation"

12. "Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload"

13. "The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box or meter or other enclosure, inside or outside the building wall. Where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building"

14. "The words 'Thermally Protected' appearing on the nameplate of a motor-compressor indicate that the motor is provided with a thermal protector"

15. "Constructed or protected so that exposure to the weather will not interfere with successful operation"

16. "Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors"

17. "The total components and subsystems that in combination, convert solar energy into electrical energy suitable for connection to a utilization load"

18. "The point of connection between the facilities of the serving utility and premises wiring"

19. "Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, and so forth"

20. "Surrounded by a case, housing, fence, or wall(s) that prevents persons from accidentally contacting energized parts"

Answers to Assignment Sheets

Assignment Sheet 4

Use the *National Electrical Code* to answer general questions related to residential wiring

a. Yes; 314.40(A)
b. Acceptable to the authority having jurisdiction; 100
c. No; 210.23(A)(2)

Assignment Sheet 5

Use the *National Electrical Code* to locate allowable ampacities for various conductors

a. 22.75 (25 x .9); cannot be fused over 15A; 240.4(D)
b. 150.15 (165 x .91)
c. 183.3 (195 x .94)
d. 47 (50 x .94); cannot be fused over 30A; 240.4(D)
e. 27 (25 x 1.08) cannot be fused over 25A; 240.4(D)
f. 21.6 (20 x 1.08) cannot be fused over 15A; 240.4(D)
g. 108 (100 x 1.08)
h. 43.2 (40 x 1.08)

Assignment Sheet 6

Use the *National Electrical Code* to interpret conduit fill tables

1 .

a. 358.22
   1. 12
   2. 5
   3. 1

b. 348.22
   1. 10
   2. 2

c. 344.22
   1. 5
   2. 3
   3. 7

d. 342.22
   1. 5
   2. 4

e. English calculation:
#3 THHN = .0973 in.^{2} x 2 = .1946
#6 THHN = .0507 in.^{2} x 1 = +.0507
.2453 square inches

Metric calculation:
#3 THHN = 62.77 mm.^{2} x 2 = 125.54
#6 THHN = 32.71 mm.^{2} x 1 = +32.71
158.25 square millimeters

Solution: 1" diameter EMT (trade size) or #27 diameter EMT (metric size)

Answers to Assignment Sheets

Assignment Sheet 7
Part 1

Find information in the *National Electrical Code*

a. Article part A, *Code* section 250.1
    1. “Systems, circuits, and equipment required, permitted, or not permitted to be grounded”
    2. “Circuit conductor to be grounded on grounded systems”
    3. “Location of grounding connections”
    4. “Types and sizes of grounding and bonding conductors and electrodes”
    5. “Methods of grounding and bonding”
    6. “Conditions under which guards, isolation, or insulation may be substituted for grounding”

b. Article part II; 250.34(A); True
c. Article part II; 250.30(A)(4); True
d. Provided; fault current; Article part V; 250.90
e. Insulated, covered, accessible; Article part VI; 250.119(A)
f. Jumper; Article part V: 250.102(A)
g. Inside, outside; Article part V; 250.102(E)
h. Article part VI; 250.122(A); #8, #6, #3, (Table 250.122)
i. Cases or frames; Article part IX; 250.172
j. Spliced, solder; Article part VII; 250.148

Part 2

a. True; *Code* section 334.12(A), (10) c.
b. 6 feet (1.8m); *Code* section 334.23 ref. to 320.23(A)
c. False; *Code* section 342.2
d. True; *Code* section 344.14
e. True; *Code* section 346.8
f. True; *Code* section 352.30(B), table
g. True; *Code* section 358.28(B)
h. True; *Code* section 360.12 (6)
i. True; *Code* section 360.20(A), exception no. 2
j. True; *Code* section 368.2

Part 3

a. True; *Code* section 430.7(A)(2)
b. Motor control circuit; *Code* section 430.71
c. False; *Code* section 430.110(B)
d. True; *Code* section 440.22(A)
e. False; *Code* section 445.13
f. True; *Code* section 450.47
g. True; *Code* section 480.2, ref. to 480.10(B)
h. True; *Code* section 500.5(B)
i. False; *Code* section 501.5(A)(1)

Part 4

a. 12, 10; *Code* section 230.31(B)(exception)
b. False; *Code* section 402.12 ref. to table 240.5(B)(2)
c. True; *Code* section 314.16(C)(2)
d. Covers; *Code* section 314.28(C)
e. True; *Code* section 310.15(B)(3)
f. 300.4; *Code* section 334.17
g. 5 minute; *Code* section 460.28(A)
h. True; *Code* section 500.6(B)(1)
i. False; *Code* section 680.22(A)(5)

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms related to using trade information with their correct definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. American National Standards Institute (ANSI)
2. American Standard Association (ASA)
3. Bonding
4. Bonding jumpers
5. Bonding jumper circuit
6. Bonding jumper equipment
7. Building code
8. Grounded
9. Grounded conductor
10. Grounding conductor
11. Grounding electrode conductor
12. Jurisdiction
13. Mandatory enforcement
14. *National Electrical Code* (*NEC*)
15. National Electrical Manufacturers Association (NEMA)
16. National Fire Protection Association (NFPA)
17. Underwriters Laboratories (UL)

_____ a. Develops electrical equipment standards

_____ b. Develops standards for electrical machinery and equipment

_____ c. Develops and publishes fire and industrial safety standards

_____ d. Develops standards for electrical equipment and supplies

_____ e. Tests equipment and lists items for use in specified situations

_____ f. Standards developed to provide for safe building construction practices

_____ g. Intentionally grounded system or circuit conductor

_____ h. Book containing electrical specifications endorsed by NFPA and ANSI; used for legal and regulatory purposes in the interest of life and property protection

_____ i. Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

_____ j. Conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system

_____ k. Connections between two or more portions of the equipment grounding conductor

_____ l. Power, right, or authority to interpret the law (code)

_____ m. Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

_____ n. Governmental authority to demand compliance with the *National Electrical Code* requirements for electrical installations

_____ o. Conductor used to connect equipment of the grounded circuit of a wiring system to a grounding electrode or electrodes

_____ p. A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected

_____ q. Connected to earth or to some conduction body that serves in place of the earth

Objective 2 State the purpose of the *National Electrical Code.*

____

____

____

____

Objective 3 List factors that are not covered by the *National Electrical Code.*

a. ______________________________

b. ______________________________

c. ______________________________

Objective 4 State the intent of the *National Electrical Code* regarding mandatory enforcement.

____

____

____

____

Written Test

Objective 5

Match *National Electrical Code* chapter numbers with their areas of application. Write the correct numbers in the blanks.

1. Chapter 1
2. Chapter 2
3. Chapter 3
4. Chapter 4
5. Chapter 5
6. Chapter 6
7. Chapter 7
8. Chapter 8
9. Chapter 9

_____ a. Communications systems

_____ b. Special equipment

_____ c. General

_____ d. Tables

_____ e. Special conditions

_____ f. Special occupancies

_____ g. Wiring and protection

_____ h. Equipment for general use

_____ i. Wiring methods and materials

Objective 6

Arrange in order the organizational components of *National Electrical Code* information. Write a "1" before the first step, a "2" before the second step, and so on.

_____ a. Numbered paragraphs

_____ b. Article

_____ c. Chapter

_____ d. Parts

_____ e. Numbered or uppercase lettered subparagraphs

Objective 7

Arrange in order the steps for finding information in the *National Electrical Code* information. Write a "1" before the first step, a "2" before the second step, and so on.

_____ a. Turn to article and section as designated.

_____ b. Read all related areas and exceptions.

_____ c. Refer to index for appropriate area of code.

_____ d. Cross-reference if code refers to another article.

_____ e. Locate specified area in question.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 15
b. 2
c. 16
d. 1
e. 17
f. 7
g. 9
h. 14
i. 3
j. 11
k. 6
l. 12
m. 5
n. 13
o. 10
p. 4
q. 8

Objective 2

The practical safeguarding of persons and property from hazards arising from the use of electricity

Objective 3

a. Efficiency
b. Convenience
c. Adequate for good service or future expansion

Objective 4

The *Code* is intended to be suitable for mandatory application by the governmental authority having jurisdiction. Mandatory rules are characterized by the word "SHALL" or "SHALL NOT".

Objective 5

a. 8
b. 6
c. 1
d. 9
e. 7
f. 5
g. 2
h. 4
i. 3

Objective 6

a. 4
b. 2
c. 1
d. 3
e. 5

Objective 7

a. 3
b. 4
c. 1
d. 5
e. 2

Unit 8 Basic Equipment

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 8–3
Answers to Assignment Sheets 8–7
Written Test 8–9
Answers to Written Test 8–21

Transparency Masters

1—Box Design Features 8–23
2—Box Design Features (continued) 8–25

Student Components

Student Page

Learning Activities Sheet 8–3
Objective Sheet 8–5
Information Sheet 8–7

* Assignment Sheet

1—Determine the Correct Number of Conductors for Boxfill 187

* Job Sheets

1—Install Outlet Boxes on Wood Studs on a Framed Wall 191
2—Install Outlet Boxes on Steel Structures and Rods Using Caddy Clips 197
3—Install Outlet Boxes on Steel Studs Using Caddy Metal Clips for Switch Boxes 201
4—Install Masonry Boxes in a Block Wall Using Caddy Metal Clips for Switch Boxes 205

* Assignment Sheet and Job Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM1 and 2—Box Design Features (Objective 2)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Discuss slang terms and regional terms associated with basic equipment. Devise a short quiz to determine whether students can make the proper connections between the slang and industry terms.
- Show examples of outlet boxes and electrical devices to the class.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Adams, James E. and Gordon Rockmaker. *Industrial Electricity Principles and Practices*, Third Edition. New York: McGraw-Hill Book Co., 1985.
- Early, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code*, 1993. Quincy, MA: National Fire Protection Association, 1992.
- National Electrical Code, 2002. Quincy MA: National Fire Protection Association, 2001.
- Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.

Suggested Activities

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes.* Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC

- *NEC 2002 Handbook.* Quincy, MA: National Fire Protection Association, 2001.

  Contains completed Code text plus commentary, photos, and full-color graphics

  The publication(s) listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org

- Leviton Catalog, Leviton Mfg. Co. Inc., 59-25 Little Neck Pkwy, Little Neck, NY 11362. 1-800-824-3005. http://www.leviton.com

- Miller, Chris. *Illustrated Guide to the National Electrical Code,* 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type of occupancy and contains 500 illustrations.

- Raco Steel Box Catalog, Raco Inc., P.O. Box 4002, 3902 West Sample St., South Bend, IN 46634-4002. 1-800-22-6437. http://www.racoinc.com

- Ridgid Tool Catalog, Ridgid Inc., 400 Clark Street, Elyria, OH 44035. 1-800-743-4333. http://www.ridgid.com

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code,* 6th ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied.

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.

Answers to Assignment Sheets

Assignment Sheet 1

Determine the Correct Number of Conductors for Boxfill

a. 7

b. 6

c. 0

d. 2

e. 8

f. 4

g. 4

h. 6

i. 3

j. 3

Written Test

Name ____

Date ______________________________ Score__________

Objective 1

Match the terms with their correct definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Boxfill
2. Cabinet
3. Disconnecting means
4. Dustproof
5. Dusttight
6. Explosion-proof
7. Joint Industry Conference (JIC) boxes
8. Junction boxes
9. Knockout (KO)
10. NEMA enclosures
11. Outlet boxes
12. Rainproof
13. Raintight

_____ a. Enclosures designed for conduit or cable entrances to enclose the conductor splices and taps

_____ b. So constructed, protected, or treated as to prevent rain from interfering with successful operation

_____ c. So constructed that dust will not enter the enclosing case

_____ d. So constructed or protected that exposure to a beating rain will not result in the entrance of water

_____ e. Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

_____ f. Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

_____ g. Enclosure designed either for surface or flush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

_____ h. Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

_____ i. So constructed or protected that dust will not interfere with successful operation

_____ j. Boxes or enclosures made to set standards for such uses as junction boxes and housing terminal blocks

_____ k. Electrical enclosures specially designed to standards for use in specific locations and for various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

_____ l. Device, or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

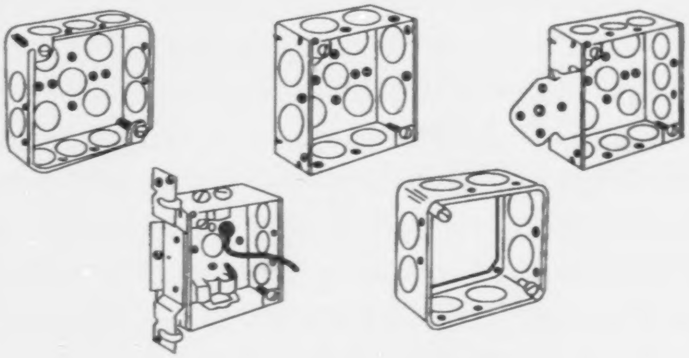
_____ m. Partially cut out piece of metal or plastic that can be forced out when a hole is needed

Objective 2

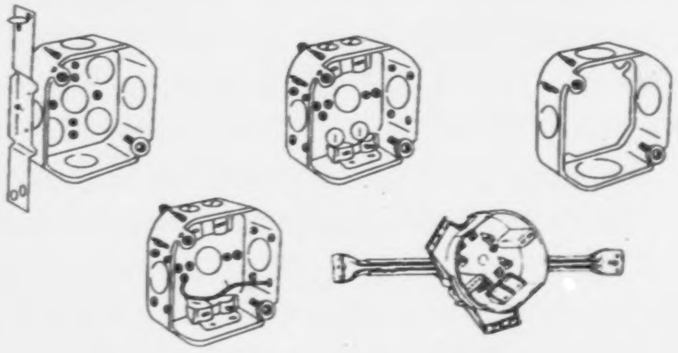
Identify the following classes of outlet boxes used in electrical wiring. Write the correct names in the blanks

Octagon boxes
Regular masonry boxes
Handy boxes

Switch boxes
Masonry through-the-wall boxes
Square boxes

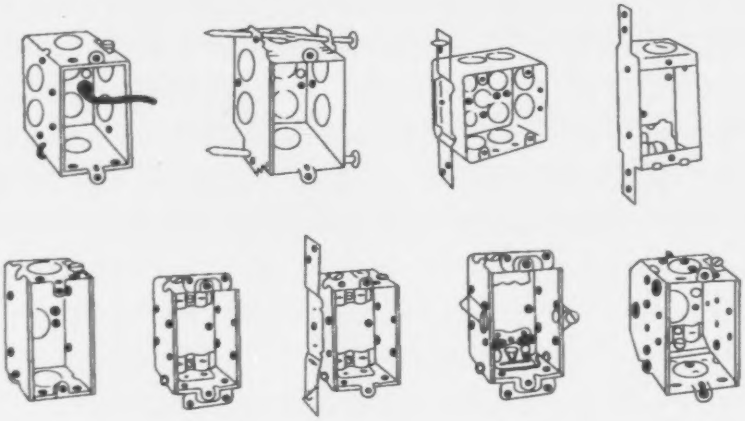


a. ______________________________

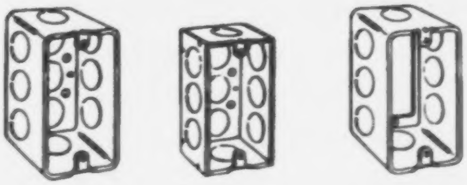


b. ______________________________

c. Outlet boxes (device boxes)

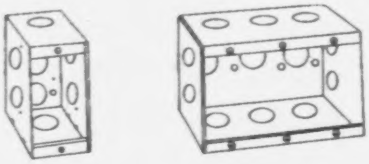


1. ______________________________

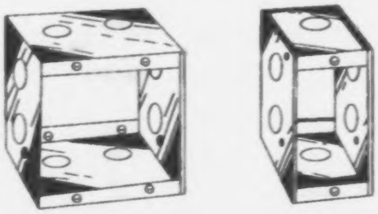


2. ______________________________

d. Masonry boxes



1. ______________________________



2. ______________________________

Written Test

Objective 3

List information needed to calculate boxfill.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 4

Match types of enclosures with their conditions for use. Write the correct numbers in the blanks.

1. Weatherproof
2. General duty
3. Corrosionproof
4. Explosion proof
5. Dustproof
6. Watertight

_____ a. For use where rain or dust could interfere with normal operation

_____ b. For use in hazardous locations

_____ c. For normal use in locations without excessive dust, moisture, or corrosive atmospheres

_____ d. For use in locations having corrosive atmospheres

_____ e. For use where dust could interfere with normal operation

_____ f. For use in wet locations

Objective 5

State the purposes of controller enclosures.

a. ______________________________

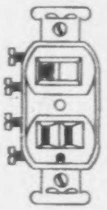
b. ______________________________

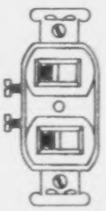
c. ______________________________

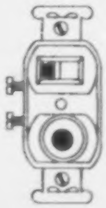
d. ______________________________

Objective 6

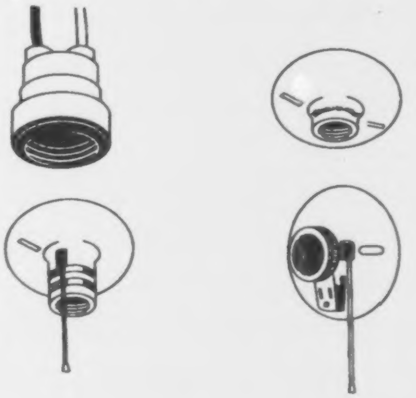
Label the following types of devices commonly used in electrical wiring.



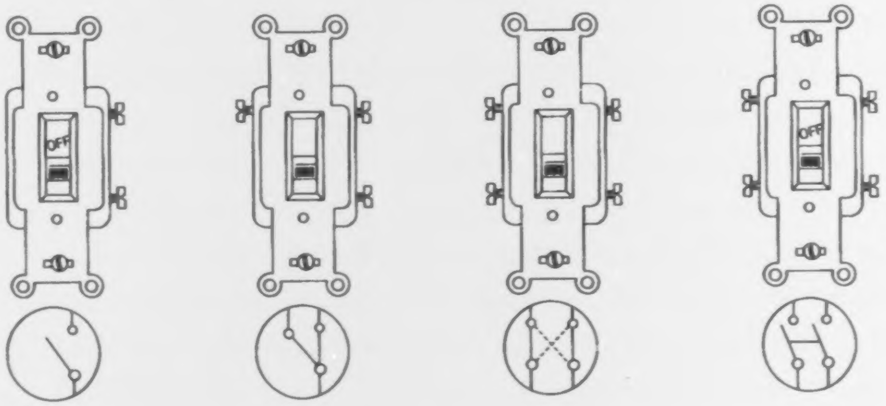




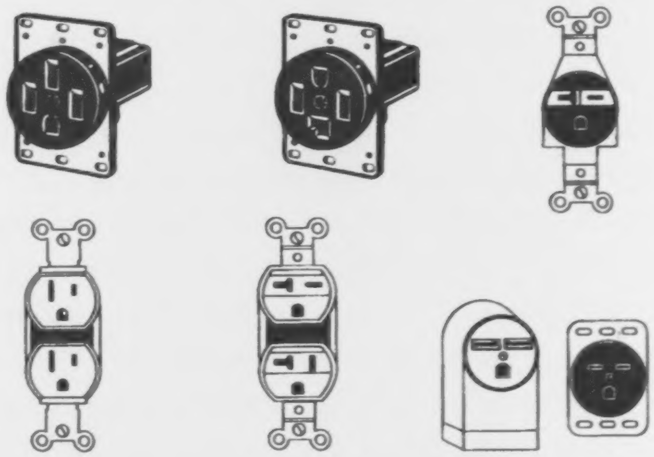
a. ______________________________



b. ____



c. ____

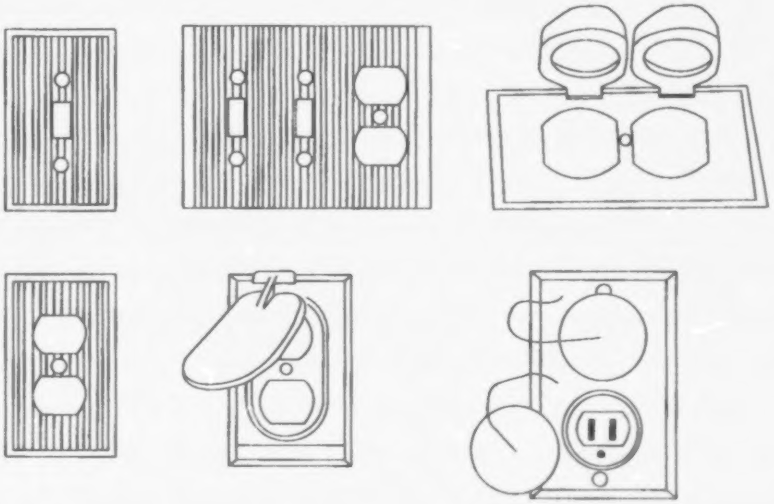


d. ____

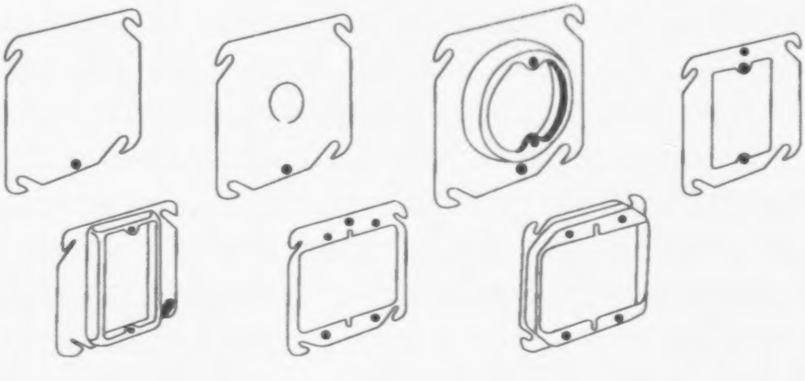
Written Test

Objective 7

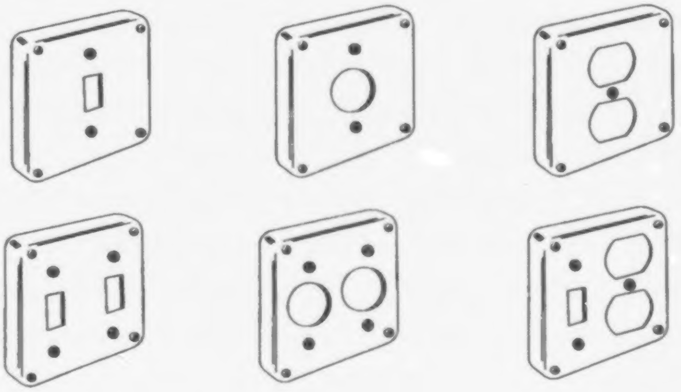
Label the following types of covers and plates used in electrical wiring.



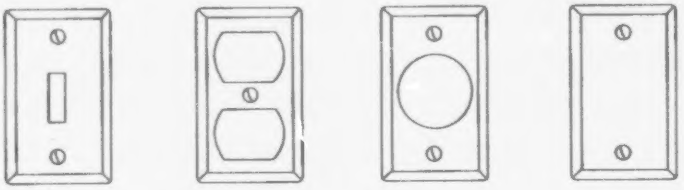
a. ____



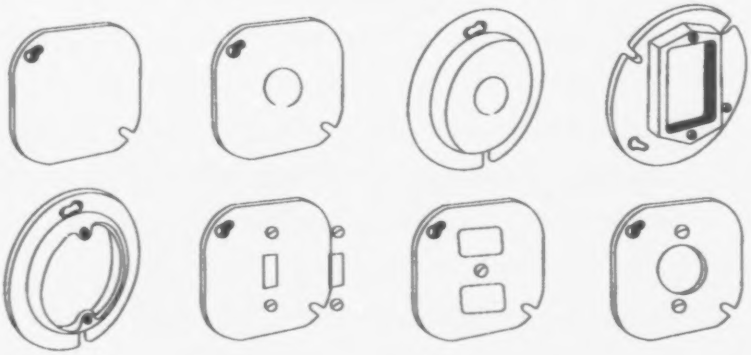
b. ____



c. ______________________________



d. ______________________________



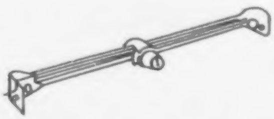
e. ______________________________

Written Test

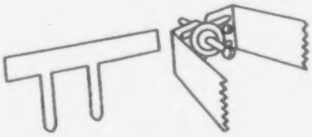
Objective 8

Identify the following supports and anchors commonly used in electrical wiring. Write the correct names in the blanks.

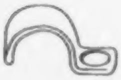
- Molly bolt
- Switch-box supports
- Two-hole strap
- Bar hanger
- Driver stud
- One-hole strap
- Lead anchor
- Plastic anchors
- Toggle bolt



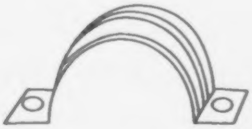
a. ______________________



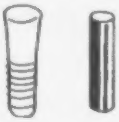
b. ______________________



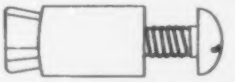
c. ______________________



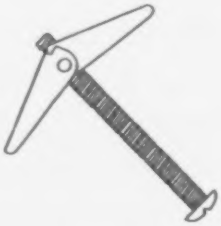
d. ______________________



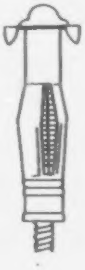
e ______________________



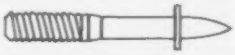
f. ______________________



g. ______________________



h. ______________________



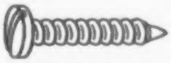
i. ______________________

Written Test

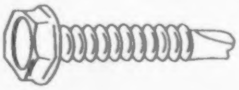
Objective 9

Identify the following screws, bolts, and nuts commonly used in electrical wiring. Write the correct names in the blanks.

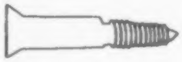
Setscrew
Woodscrew
Spring nut
Wing nut
Machine screw
Single-thread nut
Sheet metal screw
Self-drilling screw
Hex-head bolt
Plain hex nut
Fixture nut
Hex-socket-head bolt
Carriage bolt
Acorn nut



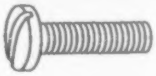
a. ______________________



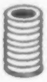
b. ______________________



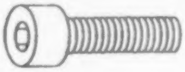
c. ______________________



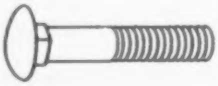
d. ______________________



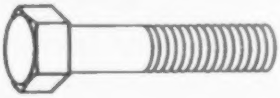
e ______________________



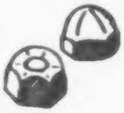
f. ______________________



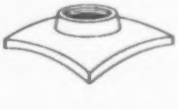
g. ______________________



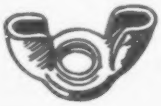
h. ______________________



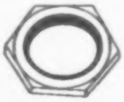
i. ______________________



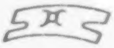
j. ______________________



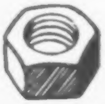
k. ______________________



l. ______________________



m. ______________________



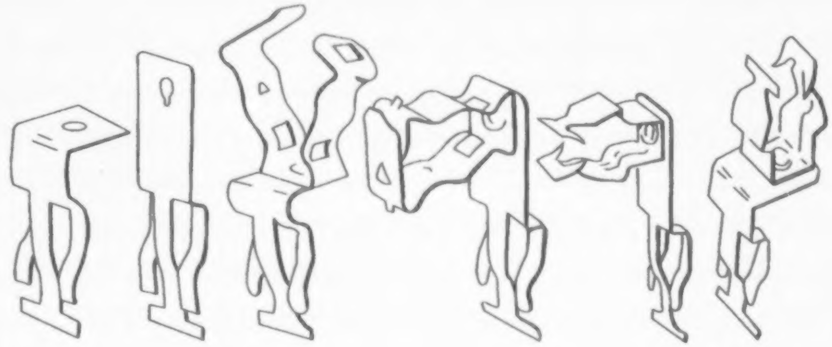
n. ______________________

Written Test

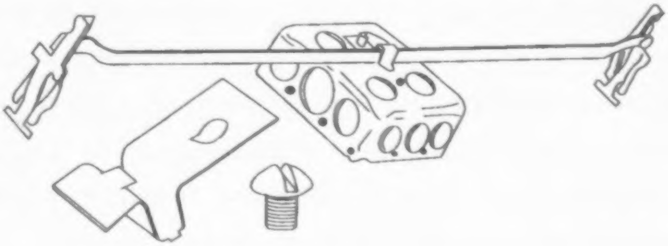
Objective 10

Identify the following classes of outlet box-mounting devices for steel structures. Write the correct names in the blanks

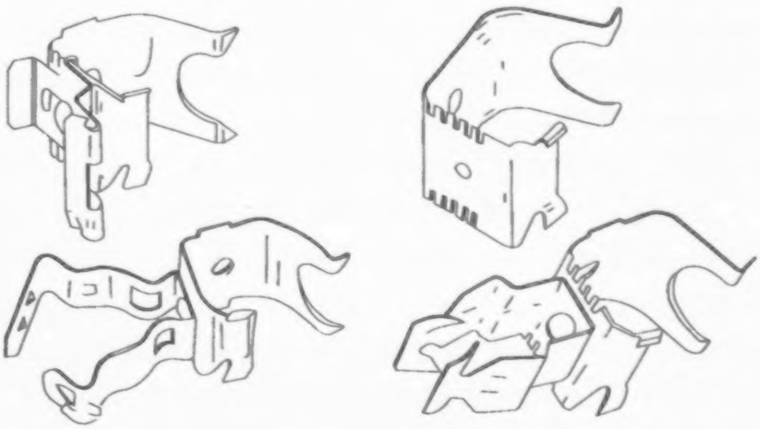
Acoustical tee-bar electrical box hanger and mounting clip
MF clip for switch boxes
Conduit box clip
Metal stud clips for switch boxes
Acoustical tee-bar clips



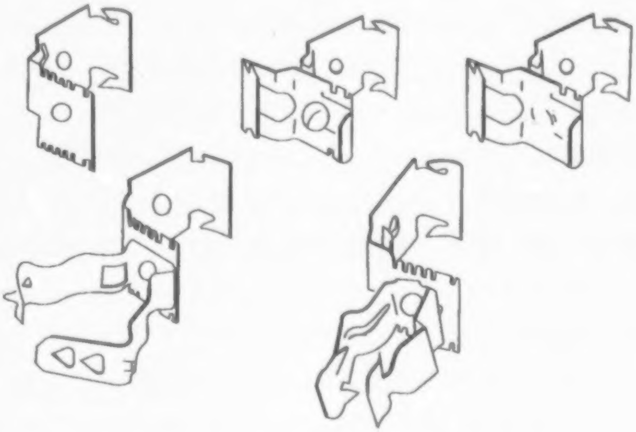
a. ______________________________



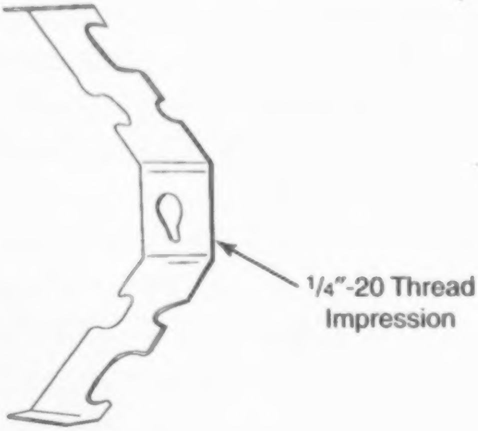
b. ______________________________



c. ______________________________



d. ______________________________


1/4"-20 Thread
Impression

e. ______________________________

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 8
b. 12
c. 5
d. 13
e. 6
f. 11
g. 2
h. 1
i. 4
j. 7
k. 10
l. 3
m. 9

Objective 2

a. Square boxes
b. Octagon boxes
c. Outlet boxes (device boxes)
    (1) Switch boxes
    (2) Handy boxes
d. Masonry boxes
    (1) Regular masonry boxes
    (2) Masonry through-the-wall boxes

Objective 3

a. Cubic inches of box
b. Size of wire
c. Number of yoke- or strap-holding devices and grounds

Objective 4

a. 1
b. 4
c. 2
d. 3
e. 5
f. 6

Objective 5

a. Keeping boxes and enclosures clean
b. Keeping boxes and enclosures dry
c. Protecting boxes and enclosures from accidental contact
d. Preventing injuries

Objective 6

a. Combination devices
b. Sockets
c. Switches
d. Receptacles

Objective 7

a. Wall plates
b. Square covers
c. Exposed work raised square covers
d. Handy box covers
e. Round covers

Answers to Written Test

Objective 8

a. Bar hanger
b. Switch box supports
c. One-hole strap
d. Two-hole strap
e. Plastic anchors
f. Lead anchor
g. Toggle bolt
h. Molly bolt
i. Drive stud

Objective 9

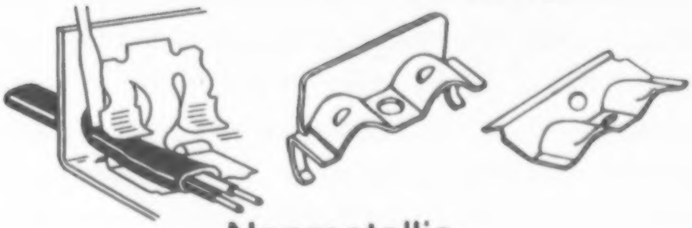
a. Sheet metal screw
b. Self-drilling screw
c. Wood screw
d. Machine screw
e. Setscrew
f. Hex-socket-head bolt
g. Carriage bolt
h. Hex-head bolt
i. Acorn nut
j. Spring nut
k. Wing nut
l. Fixture nut
m. Single-thread nut
n. Plain hex nut

Objective 10

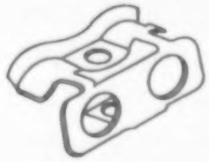
a. Acoustical tee-bar clips
b. Acoustical tee-bar electrical box hanger and mounting clip
c. Metal stud clips for switch boxes
d. MF clips for switch boxes
e. Conduit box clip

Box Design Features

Clamps

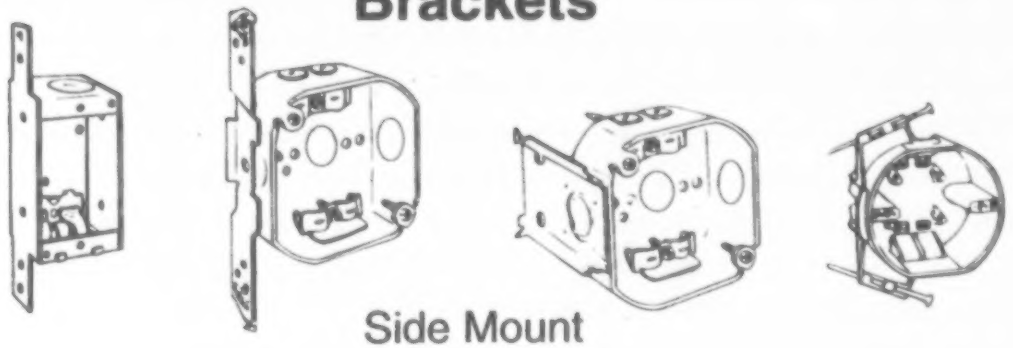


Nonmetallic
Cable Clamps

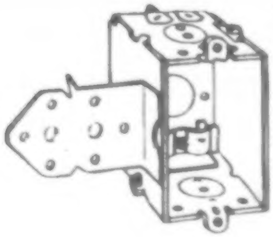


Metallic
Cable Clamp

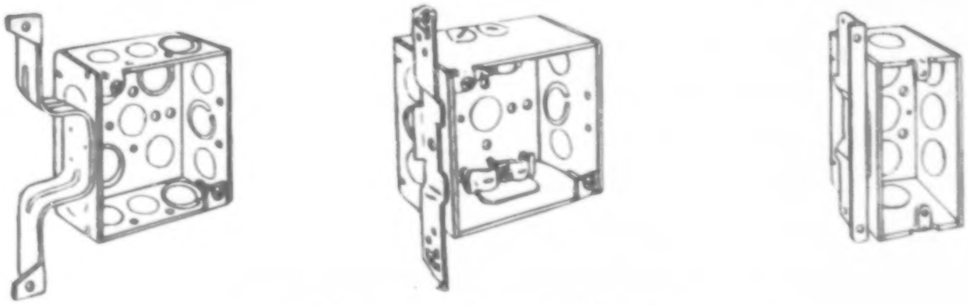
Brackets



Side Mount



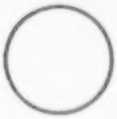
Front
Mount

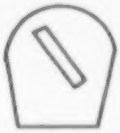


Side and Front Mount

Box Design Features (continued)

Box Openings

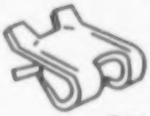

Knockout


Pry-OUt

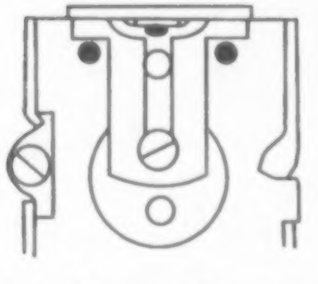
Grounding Equipment

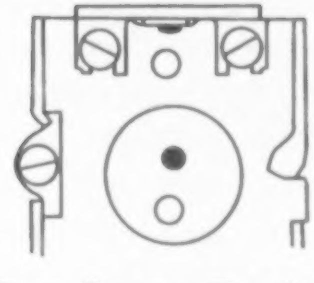
Screw

Screw with Pigtail


Clip

Plaster Ears


One-Screw Design


Two-Screw Design

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 9–3

Answers to Assignment Sheets 9–7

Written Test 9–9

Answers to Written Test 9–15

Transparency Masters

1—Friction Produces Electricity 9–17
2—Pressure Produces Electricity 9–19
3—Heat Produces Electricity 9–21
4—Light Produces Electricity 9–23
5—Chemical Action Produces Electricity 9–25
6—Magnetism Produces Electricity 9–27
7—Ohm's Law in Wheel Expression 9–29
8—Three Formulas from Ohm's Law 9–31
9—Ohm's Law for Power in Wheel Expression 9–33
10—Three Formulas from Ohm's Law for Power 9–35

Student Page

Student Components

Learning Activities Sheet 9–3

Objective Sheet 9–5

Information Sheet 9–7

* Assignment Sheets

1—Draw a Diagram of the Power Distribution Supplying Your School Shop or Home 209
2—Solve Problems for Unknown Voltage 211
3—Solve Problems for Unknown Amperage 213
4—Solve Problems for Unknown Resistances and Wattages 215
5—Solve Problems for an Unknown Quantity 217

* Assignment Sheets are located in Student Workbook 1.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM1—Friction Produces Electricity (Objective 3)
  TM2—Pressure Produces Electricity(Piezoelectric Effect) (Objective 3)
  TM3—Heat Produces Electricity (Thermocouple) (Objective 3)
  TM4—Light Produces Electricity (Objective 3)
  TM5—Chemical Action Produces Electricity (Objective 3)
  TM6—Magnetism Produces Electricity (Objective 3)
  TM7—Ohm's Law in Wheel Expression (Objective 9)
  TM8—Three Formulas from Ohm's Law (Objective 11)
  TM9—Ohm's Law for Power in Wheel Expression (Objective 13)
  TM10—Three Formulas from Ohm's Law for Power (Objective 15)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Provide students with enough practice concerning basic theory to meet local employment needs.
- Have representatives from a local power company discuss the distribution of electricity in your community. Coordinate this activity with the completion of Assignment Sheet 1.
- Have students construct a model or draw diagrams of an atom, showing its makeup.
- Show or give examples of basic sources of generation.
- Relate Ohm's law to series and parallel circuits.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Basic Electricity Review*. Rockville, MD: NUS Training Corporation, A Halliburton Company.
- Herman, Stephen L. *Electrician's Technical Reference: Electrical Theory and Calculations*. Delmar Publishers, Inc. 2002
- Miller, Rex. *Industrial Electricity*. Peoria, IL: Bennett Publishing Company.
- Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.
- Turner, J. Howard. *Understanding Electricity and Electrical Terms.* Athens, GA: American Association for Vocational Instructional Materials.

Suggested Supplemental Resources

Electronic Media

- Electrical Theory – DC Video Set (set of four)

  Video 1: Basic Electricity
  Video 2: Series and Parallel Circuits
  Video 3: Combination circuits
  Video 4: Small Sources of Electricity

  Available on video or CD-ROM, this set can be purchased online at www.delmar.com or by calling 1-800-477-3692

Answers to Assignment Sheets

Assignment Sheet 1

Draw a Diagram of the Power Distribution Supplying Your School Shop or Home

Evaluated using the assignment sheet criteria

Assignment Sheet 2

Solve Problems for Unknown Voltage

a. 120
b. 240
c. 24
d. 12
e. 230
f. 110
g. 440
h. 120
i. 115
j. 125

Assignment Sheet 3

Solve Problems for Unknown Amperage

a. 19.2
b. 10
c. 22
d. 3
e. 8
f. 50
g. 11
h. 20
i. 6
j. 12

Assignment Sheet 4

Solve Problems for Unknown Resistances and Wattages

a. 60
b. 2.5
c. 2.4
d. 46
e. 3
f. 2,640
g. 690
h. 8,800
i. 11,500
j. 12

Assignment Sheet 5

Solve Problems for an Unknown Quantity

a. $E = IR$
$2.5 \times 9.6 = 24$ volts

b. $R = E/I$
$460/100 = 4.6$ ohms

c. $P = IE$
$2.5 \times 12 = 30$ watts

d. $E = IR$
$0.500 \times 500 = 250$ volts

e. $I = P/E$
$100/120 = 0.833$ amps

f. P = EI
208 x 600 - 124,800 watts
R = E/I
208/600 = 0.347 ohms

g. I = P/E
20/50 = 0.4 amps
R = E/I
50/0.4 = 125 ohms

h. I = E/R
10/2200 = 0.0045 amps
P = IE
0.0045 x 10 = 0.045 watts

i. I = P/E
100/100 = 1 amp
R = E/I
100/1 = 100 ohms

j. R = E/I
480/1000 = 0.48 ohms
P = IE
1000 x 480 = 480,000 watts

Written Test

Name ____

Date ________________________________ Score __________

Objective 1

Match the terms related to basic electrical theory with their correct definitions. Write the correct numbers in the blanks.

1. Amp (ampere)
2. Electricity
3. Electron flow
4. Ohm
5. Volt
6. Watt

_____ a. Invisible energy

_____ b. Unit of measure of the power of an electrical circuit

_____ c. Unit of measure of the intensity of the electron flow in a circuit

_____ d. Electrons transferring from one atom to another

_____ e. Unit of measure of the opposition to electron flow in a circuit

_____ f. Unit of measure of electromotive force or potential difference

Objective 2

Select true statements concerning the principles of electron flow by placing an "X" in the blanks next to the true statements.

_____ a. Electricity is the flow of one electron to another.

_____ b. Atoms contain both protons and electrons.

_____ c. Protons always have a negative charge.

_____ d. Electrons always have a positive charge.

_____ e. Generation occurs when an outside force of power excites the electron flow and electricity is produced.

Written Test

Objective 3

Select words to complete the following list of statements concerning basic sources of electrical generation. Circle the word(s) that best completes each statement.

a. (**Chemical action, Friction**) produces electricity when two materials are rubbed together.

b. Pressure produces electricity when pressure is applied to (**crystalline, magnetic**) substances.

c. Heat produces electricity when it is applied to the junction of two (**similar, dissimilar**) metals.

d. Light produces electricity when it strikes a (**reflective, photosensitive**) material.

e. (**Chemical action, Friction**) produces electricity when that action takes place between two metals in a cell.

f. Magnetism produces electricity when a magnet is moved past (**another magnet, a piece of wire**).

Objective 4

Complete statements concerning distribution of electricity by filling in the blanks with the word(s) that best completes each statement.

a. Power is produced at the ____________________ ____________________.

b. Voltage is ____________________ ____________________ for high-voltage transmission.

c. Voltage is moved from one area to another through high-voltage ____________________ ____________________.

d. Voltage is stepped down and moved through ____________________ for public use.

Written Test

Objective 5

Match electrical schematic symbols with their names. Write the correct numbers in the blanks.

_____ a. Normally closed contact

_____ b. Thermal resistor

_____ c. Ground connection

_____ d. Single-pole, single-throw switch

_____ e. Alternating current motor

_____ f. Temperature actuated switch (opens on rise)

_____ g. Transformer

_____ h. Fuse

_____ i. Fixed resistor or load

_____ j. Wire connection

_____ k. Three-way switch

_____ l. Circuit breaker

_____ m. Double-pole, single-throw switch

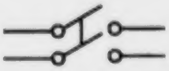
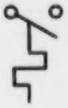
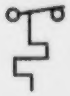
_____ n. Incandescent lamp

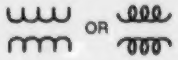
_____ o. Wire crossover

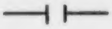
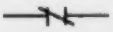
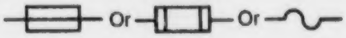
_____ p. Variable resistor or load

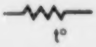
_____ q. Temperature-actuated switch (closes on rise)

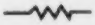
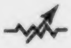
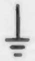
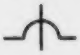
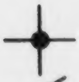
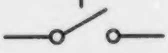
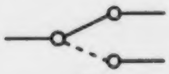
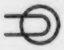
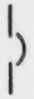
_____ r. Normally open contact

1. 
2. 
3. 
4.

5. 

6. 
7. 
8. 

9. 

10. 
11. 
12. 
13. 
14. 
15. 
16. 
17. 
18. 

Written Test

Objective 6

Distinguish between diagrams and schematics. Write a "D" in the blank before the description of diagram.

_____ a. Drawing-type illustrations of actual equipment and devices

_____ b. Line-type illustrations that use symbols for equipment and devices

Objective 7

Select units of measure to complete definitions of electrical abbreviations. Circle the correct unit of measure.

a. E—Electromotive force in (watts, volts)

b. I—Intensity in (amps, ohms)

c. R—Resistance in (volts, ohms)

d. P—Power in (watts, amps)

Objective 8

State Ohm's law.

____

____

____

Objective 9

Draw Ohm's law in wheel expression.

Objective 10 List three uses of Ohm's law.

a.

b.

c.

Objective 11 State the unit of measure formulas from Ohm's law.

a. Volts =

b. Amps =

c. Ohms =

Objective 12 State Ohm's law for power.

Objective 13 Draw Ohm's law for power in wheel expression

Objective 14 List three uses of Ohm's law for power

a.

b.

c.

Written Test

Objective 15

State the unit of measure formulas from Ohm's law.

a. Watts = ______________________________

b. Amps = ______________________________

c. Volts = ______________________________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 2
b. 6
c. 1
d. 3
e. 4
f. 5

Objective 2

a, b, e

Objective 3

a. Friction
b. Crystalline
c. Dissimilar
d. Photosensitive
e. Chemical action
f. A piece of wire

Objective 4

a. Generating plant
b. Stepped up
c. Transmission lines
d. Transformers

Objective 5

a. 7
b. 9
c. 12
d. 15
e. 4
f. 3
g. 5
h. 8
i. 10
j. 14
k. 16
l. 18
m. 1
n. 17
o. 13
p. 11
q. 2
r. 6

Objective 6

a

Objective 7

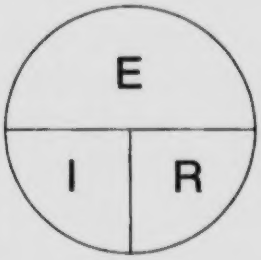
a. Volts
b. Amps
c. Ohms
d. Watts

Objective 8

Ohm's law—The current in an electric circuit equals the pressure (volts) divided by the resistance.

Answers to Written Test

Objective 9



Objective 10

a. Calculating circuit resistance
b. Calculating circuit amperage
c. Calculating circuit voltage

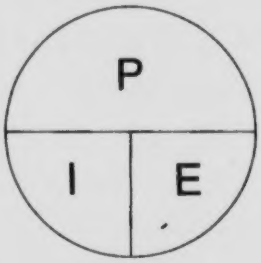
Objective 11

a. Volts = Amps x Ohms or $E = I \times R$
b. Amps = Volts ÷ Ohms or $I = E/R$
c. Ohms = Volts ÷ Amps or $R = E/I$

Objective 12

Ohm's law for power—The power in an electrical circuit equals the current (amperes) multiplied by the electromotive force (volts).

Objective 13



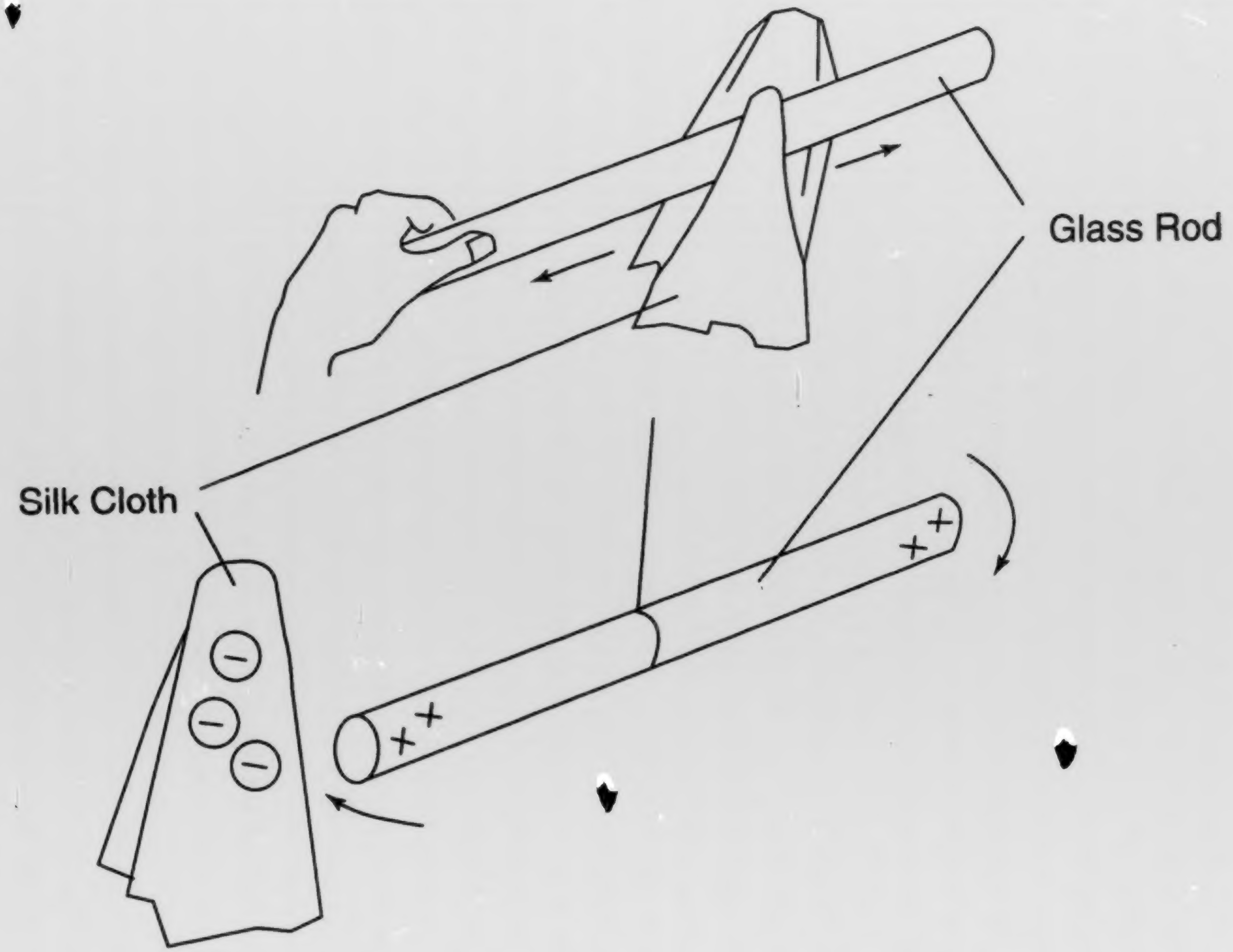
Objective 14

a. Calculating circuit wattage
b. Calculating circuit voltage
c. Calculating circuit amperage

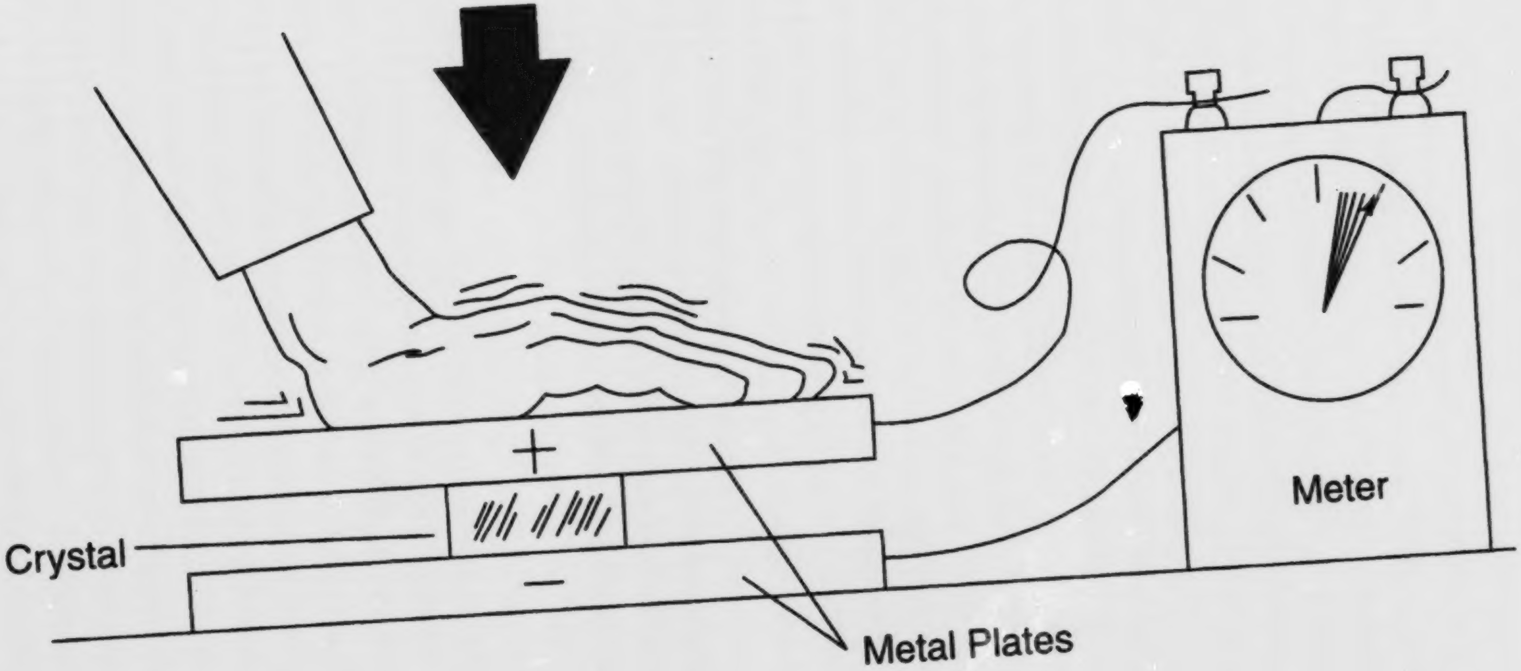
Objective 15

a. Watts = Amps x Volts or $P = I \times E$
b. Amps = Watts ÷ Volts or $I = P/E$
c. Volts = Watts ÷ Amps or $E = P/I$

Friction Produces Electricity


Glass Rod
Silk Cloth

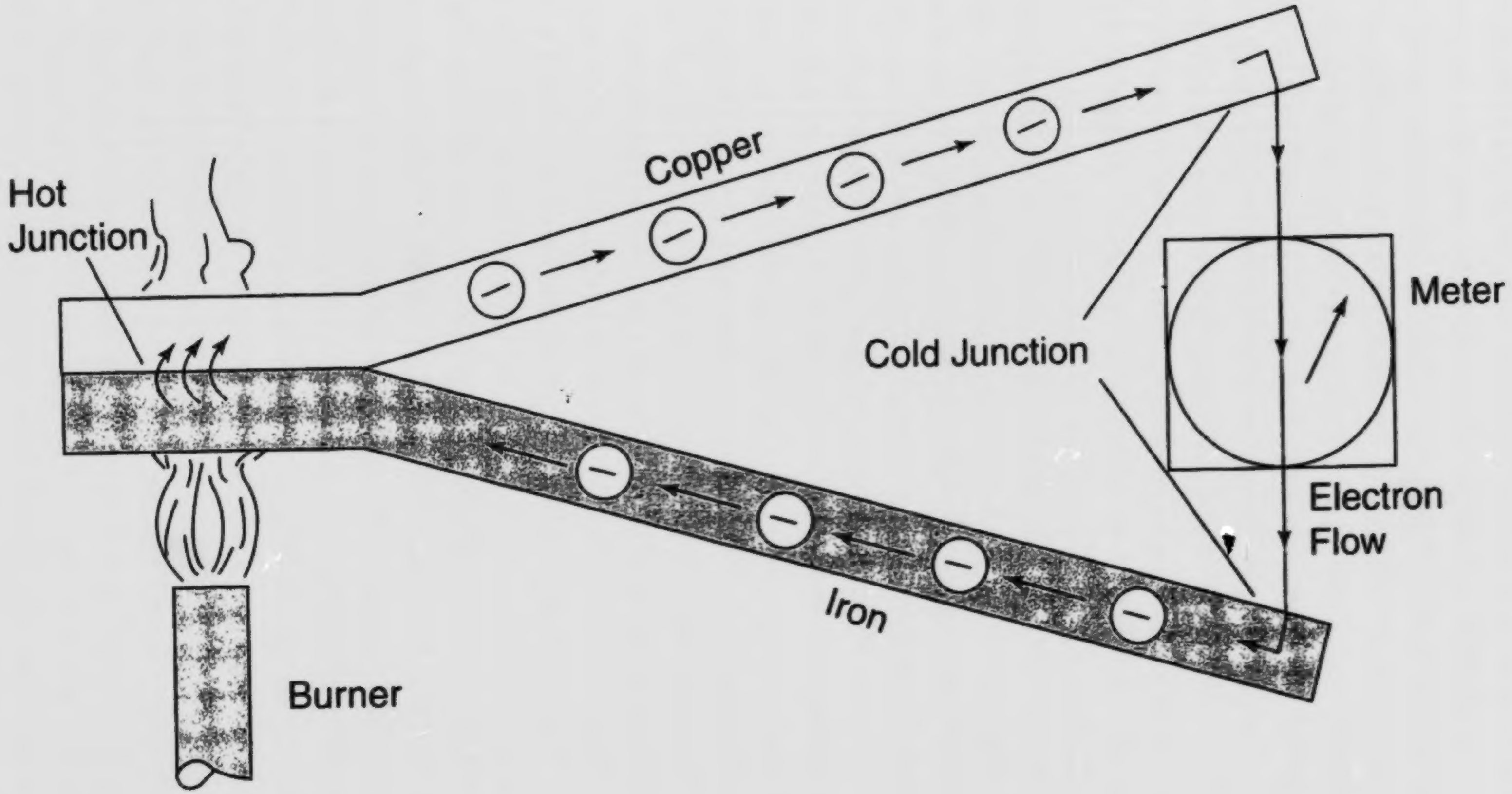
Pressure Produces Electricity (Piezoelectric Effect)


+
Crystal
−
Metal Plates
Meter

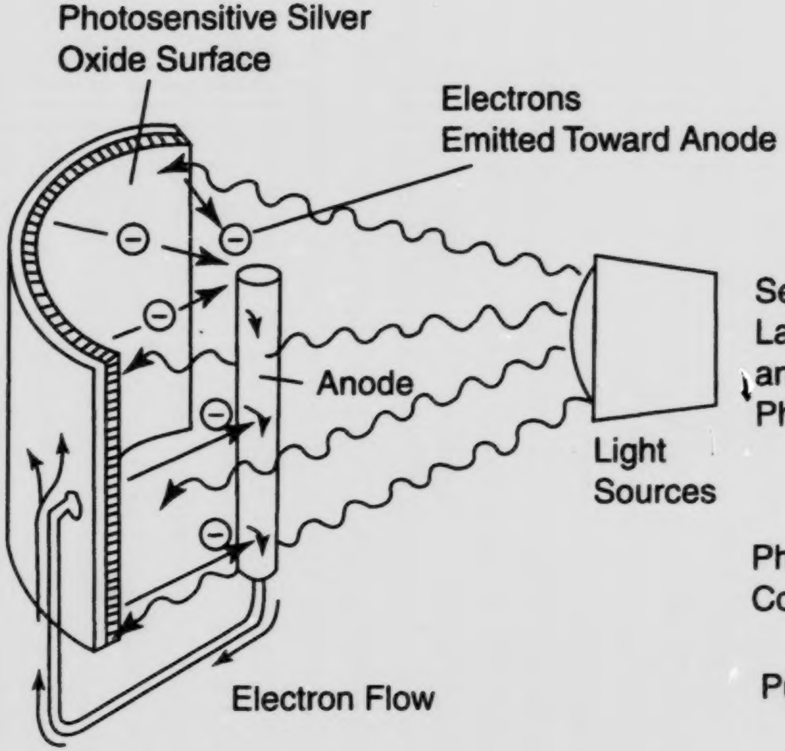
TM 2

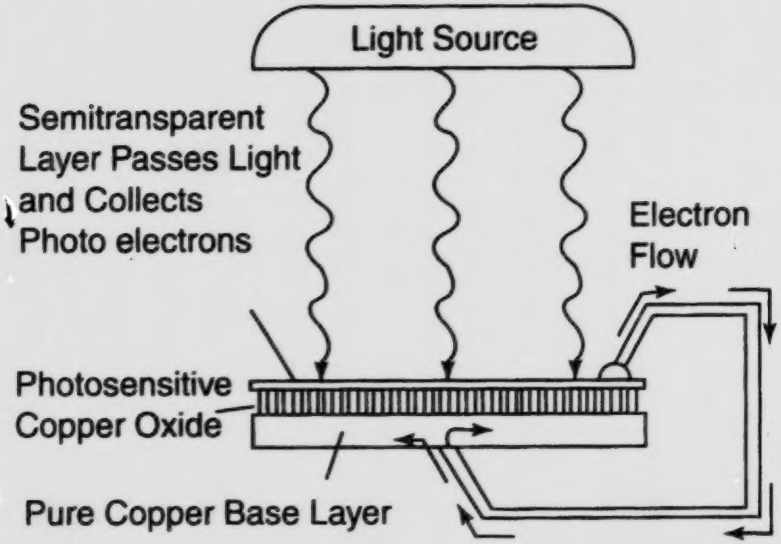
T 9–19

Heat Produces Electricity
(*Thermocouple)

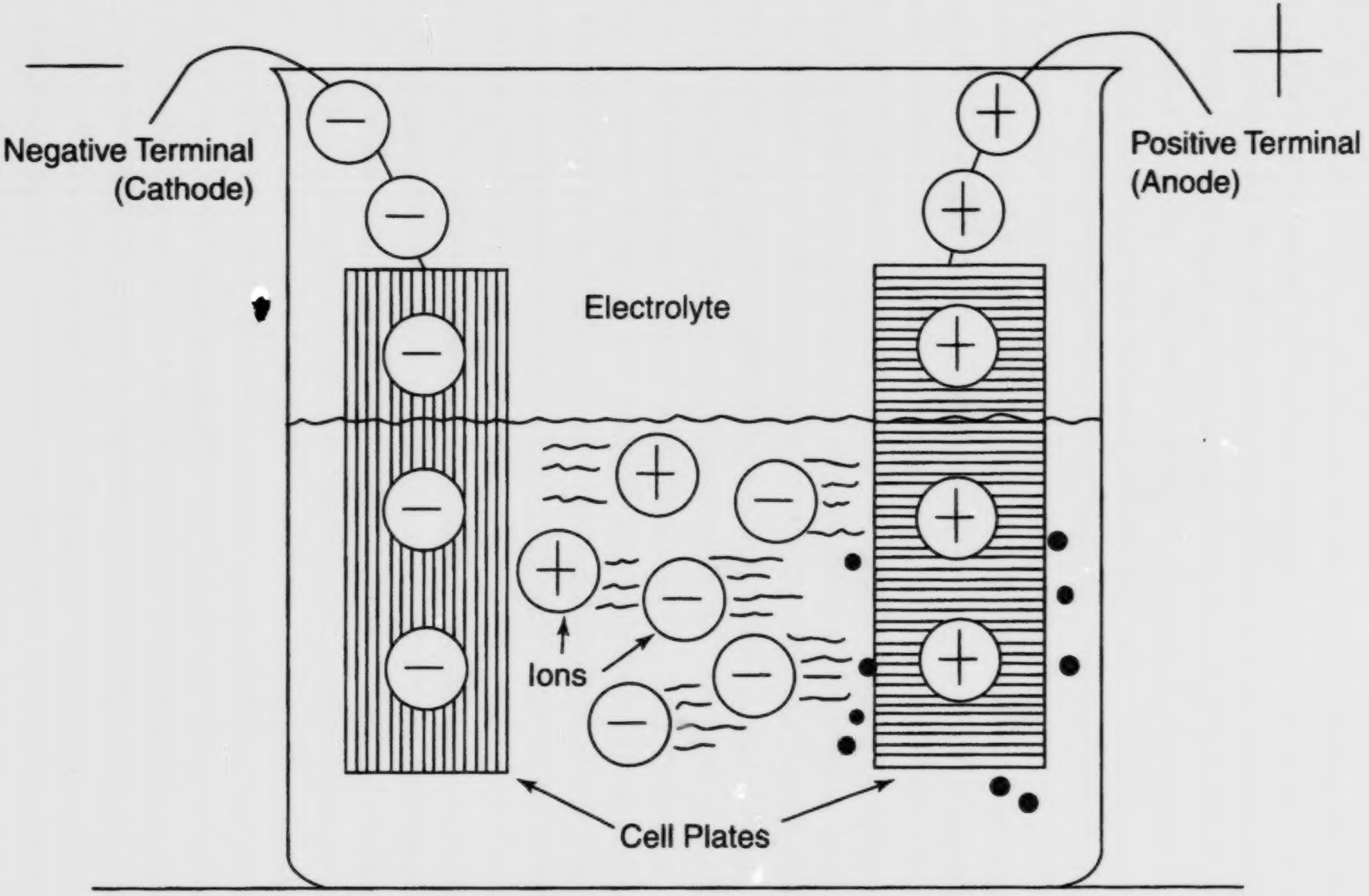

Hot Junction
Copper
Cold Junction
Meter
Electron Flow
Iron
Burner

Light Produces Electricity

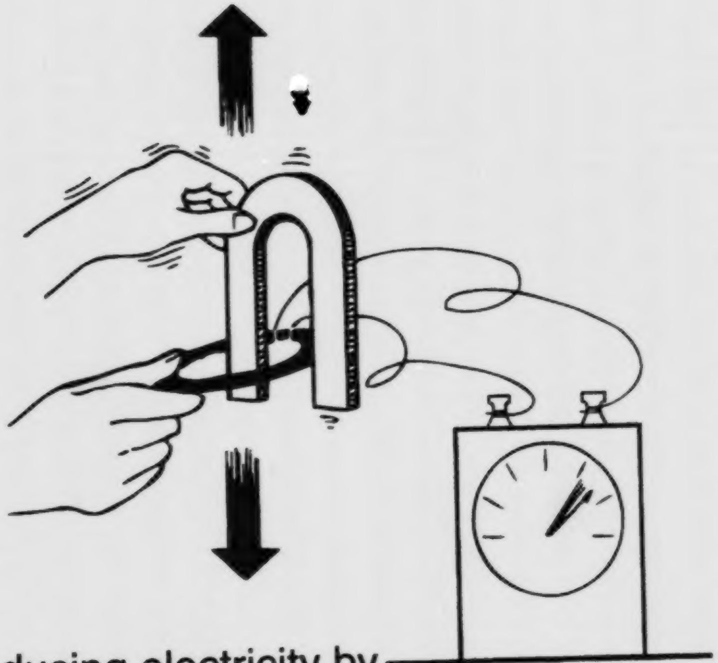

Photosensitive Silver
Oxide Surface
Electrons
Emitted Toward Anode
Anode
Light
Sources
Electron Flow


Light Source
Semitransparent
Layer Passes Light
and Collects
Photo electrons
Electron
Flow
Photosensitive
Copper Oxide
Pure Copper Base Layer

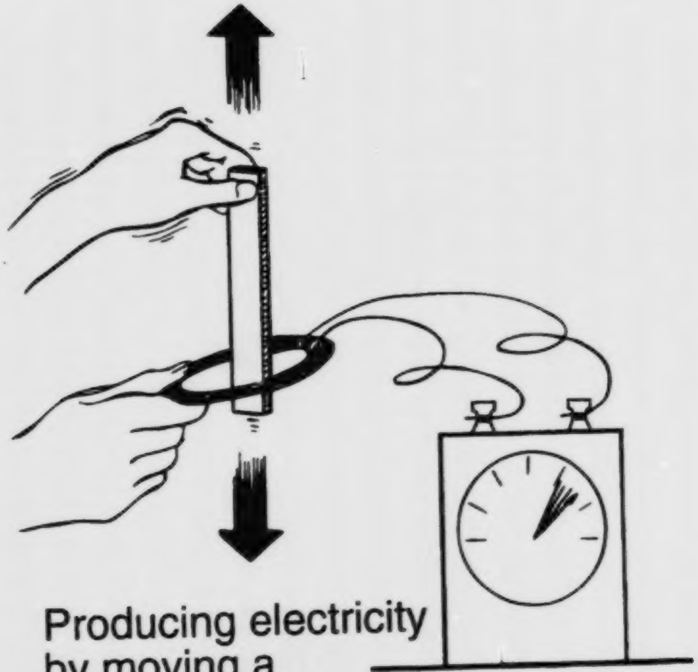
Chemical Action Produces Electricity


Negative Terminal
(Cathode)
Positive Terminal
(Anode)
Electrolyte
Ions
Cell Plates

Magnetism Produces Electricity



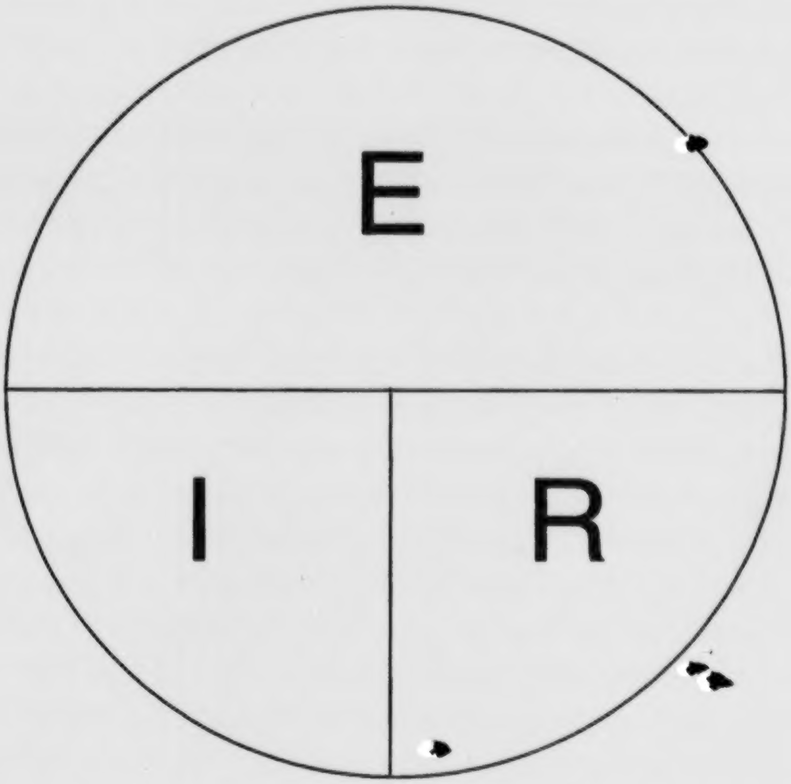
Producing electricity by moving a horseshoe magnet through a coil of wire



Producing electricity by moving a bar magnet through a coil of wire

This principle is used in generators.

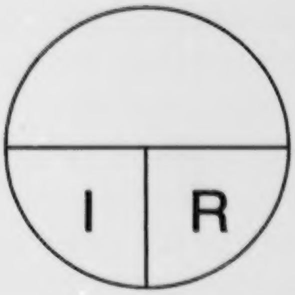
Ohm's Law in Wheel Expression



I = Amps
R = Ohms
E = Volts

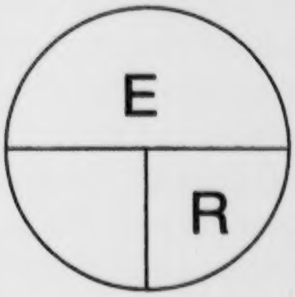
Three Formulas from Ohm's Law

E =



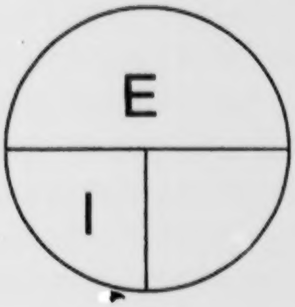
or E = I x R
or Volts = Amps x Ohms

I =



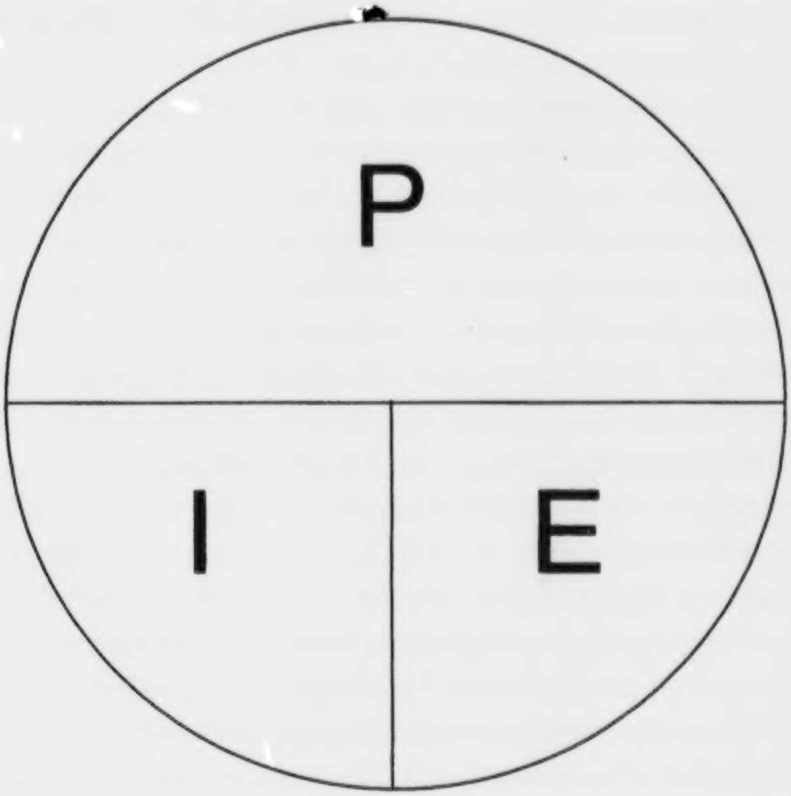
or I = E/R
or Amps = Volts ÷ Ohms

R =



or R = E/I
or Ohms = Volts ÷ Amp

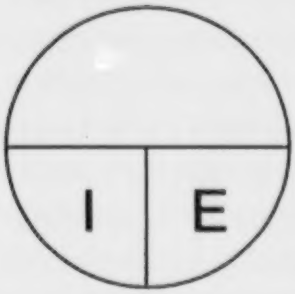
Ohm's Law for Power in Wheel Expression



P = Watts
I = Amps
E = Volts

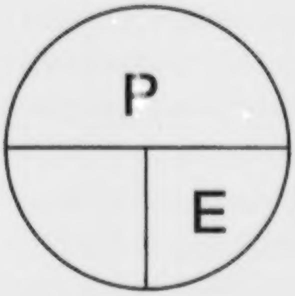
Three Formulas from Ohm's Law for Power

P =



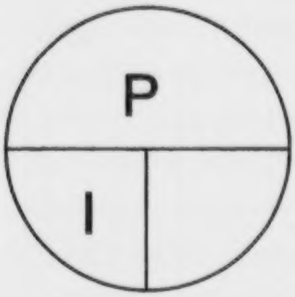
or P = I x E
or Watts = Amps x Volts

I =



or I = P/E
or Amps = Watts ÷ Volts

E =



or E = P/I
or Volts = Watts ÷ Amps

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 10–3

Answers to Assignment Sheets 10–7

Written Test 10–11

Answers to Written Test 10–15

Transparency Masters

1—Basic Electrical Circuit 10–17
2—Series Circuit 10–19
3—Applying Watt's Law 10–21
4—Parallel Circuit 10–23

Student Page

Student Components

Learning Activities Sheet 10–3

Objective Sheet 10–7

Information Sheet 10–9

Student Supplements

1—Facts About Magnetism 10–21

* Assignment Sheets

1—Solve Problems for Unknown Current 1
2—Solve Problems for Unknown Resistance 3
3—Solve Problems for Unknown Voltage 5
4—Determine Total Resistance in Series Circuits 7
5—Determine Unknown Resistance Values in Series Circuits 9
6—Solve Problems for Unknown Current in Series Circuits 11
7—Solve Problems for Unknown Resistance in Series Circuits 13
8—Solve Problems for Unknown Voltage in Series Circuits 15
9—Apply Kirchoff's Voltage Law to Series Circuits 17
10—Solve Problems for Unknown Resistance in Parallel Circuits 19
11—Solve Problems for Unknown Current in Parallel Circuits 21
12—Apply Kirchoff's Current Law to Parallel Circuits 23
13—Solve Problems for Unknown Resistance in Series-Parallel Circuits 25
14—Solve Problems for Unknown Voltage in Series-Parallel Circuits 27
15—Solve Problems for Unknown Current in Series-Parallel Circuits 29
16—Compute Power Using Ohm's Law 31

* Assignment Sheets are located in Student Workbook 2.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM1—Basic Electrical Circuit (Objective 3)
  TM2—Series Circuit (Objective 4)
  TM3—Applying Watt's Law (Objective 5)
  TM4—Parallel Circuit (Objective 6)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students work DC circuits on the chalkboard.
- Set up a display of various resistors and explaining their functions.
- Demonstrate the principles of magnetism; electromagnetism, and polarity, and explain their relationship to electricity.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Adams/Rockmaker. *Industrial Electricity.* Brooklyn, NY: McGraw-Hill Book Company, 1985.
- *DC Fundamentals Review.* Rockville, MD: NUS Training Corporation, a Haliburton Company.
- *Electromagnetic Induction Review.* Rockville, MD: NUS Training Corporation, a Halliburton Company.
- Vorderstrasse, Ron. *General Electronics Technician.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes.* Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC

Suggested Activities

- *NEC 2002 Handbook.* Quincy, MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics

  The publication(s) listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org

- Herman, Stephen L. *Electrician's Technical Reference: Electrical Theory and Calculations.* Delmar Publishers, Inc. 2002.

- Miller, Chris. *Illustrated Guide to the National Electrical Code,* 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type of occupancy, and contains 600 illustrations

- O'Riley, Ronald. *Electrical Grounding,* 6th ed. Delmar Publishers, Inc. 2002.

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code,* 6th ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied.

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.

Electronic Media

- Electrical Theory – DC Video Set (set of four)

  Video 1: Basic Electricity
  Video 2: Series and Parallel Circuits
  Video 3: Combination circuits
  Video 4: Small Sources of Electricity

  Available on video or CD-ROM, this set can be purchased online at www.delmar.com or by calling 1-800-477-3692

Answers to Assignment Sheets

Assignment Sheet 1

Solve Problems for Unknown Current

a. 0.25A
b. 0.8A
c. 0.6A
d. 2A
e. 0.89A

Assignment Sheet 2

Solve Problems for Unknown Resistance

a. 6Ω
b. 24Ω
c. 6.67Ω
d. 24Ω
e. 80Ω

Assignment Sheet 3

Solve Problems for Unknown Voltage

a. 500V
b. 800V
c. 1200V
d. 2800V
e. 800V

Assignment Sheet 4

Determine Total Resistance in Series Circuits

a. 85Ω
b. 155Ω
c. 280Ω
d. 200Ω
e. 115Ω

Assignment Sheet 5

Determine Unknown Resistor Values in Series Circuits

a. 15Ω
b. 50Ω
c. 30Ω
d. 20Ω
e. 0.6Ω

Assignment Sheet 6

Solve Problems for Unknown Current in Series Circuits

a. 1.2A
b. 0.67A
c. 0.8A
d. 0.64A
e. 0.15A

Answers to Assignment Sheets

Assignment Sheet 7

Solve Problems for Unknown Resistance in Series Circuits

a. 13.33Ω
b. 2.4Ω
c. 2.4Ω
d. 80Ω
e. 10Ω

Assignment Sheet 8

Solve Problems for Unknown Voltage in Series Circuits

a. 10V
b. 4V
c. 5V
d. 24V
e. 2.4V

Assignment Sheet 9

Apply Kirchoff's Voltage Law to Series Circuits

a. 20V
b. 5.2V
c. 12.6V
d. 42.3V
e. 34V

Assignment Sheet 10

Solve Problems for Unknown Resistors in Parallel Circuits

a. 6.67Ω
b. 14.29Ω
c. 2.29Ω
d. 2.11Ω
e. 1.05Ω

Assignment Sheet 11

Solve Problems for Unknown Current in Parallel Circuits

a. 1.05A
b. 1.83A
c. 7.80A
d. 13A
e. 1.83A

Assignment Sheet 12

Apply Kirchoff's Current Law to Parallel Circuits

a. 7.2A
b. 31A
c. 22.9A
d. 0.45A
e. 0.62A

Assignment Sheet 13

Solve Problems for Unknown Resistance in Series-Parallel Circuits

a. 30Ω
b. 44.44Ω
c. 31.11Ω

Assignment Sheet 14

Solve Problems for Unknown Voltage in Series-Parallel Circuits

a. 4V
b. 8V
c. 6V
d. 5V
e. 1V

Assignment Sheet 15

Solve Problems for Unknown Current in Series-Parallel Circuits

A. 1. Total — 1A
   2. Branch #1 — .8A
   3. Branch #2 — .2A
B. 1. Total — .16A
   2. Branch #1 — .1A
   3. Branch #2 — .06A

Assignment Sheet 16

Compute Power Using Ohm's Law

a. 25W
b. .6W
c. 125W
d. 1.6W
e. 19.6W

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match the terms related to DC circuits with their correct definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Amperage
2. Circuit
3. Conductors
4. Direct current
5. Domains
6. Electromagnet
7. Flux lines
8. Formula
9. Magnetism
10. Parallel circuit
11. Polarity
12. Power
13. Resistance
14. Series circuit
15. Series-parallel circuit
16. Voltage
17. Voltage drop
18. OHM
19. Resistor

_____ a. A mathematical expression used to find unknowns

_____ b. A complete path for current to flow from the source through the load and back to the source

_____ c. Reduction in circuit potential difference due to resistance

_____ d. Opposition to electron flow in a conductor or circuit

_____ e. Power around a magnet

_____ f. Molecules that act as small magnets when arranged end to end

_____ g. Electrical current flow; electron flow, must be measured at a point within a circuit

_____ h. An electrical current flowing in one direction only and substantially constant in value

_____ i. Materials that permit the free flow of electrons

_____ j. The measurement of the potential difference between conductors in a circuit

_____ k. When magnetism leaves a body north and enters south

_____ l. A circuit that contains some components in series and some in parallel

_____ m. Device which opposes the flow of electrical energy

_____ n. Rate of consumption of energy

_____ o. A magnet made by winding a conductor around a metal core with voltage applied

Written Test

_____ p. Property of by certain materials that exerts a mechanical force on other magnetic materials, and can cause induced voltage in conductors when relative movement is present

_____ q. A circuit that provides more than one path for current flow

_____ r. A circuit that provides only one path for current flow

_____ s. Unit of measure of the opposition to electron flow in a circuit

Objective 2

List six applications of DC circuits.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

Objective 3

State the application of Ohm's law to direct current

____

____

____

Objective 4

Select true statements about characteristics of series circuits. Write an "X" in the blank before each true statement.

_____ a. Current in a series circuit flows only one way through components connected end-to-end, forming a continuous loop and returning to the power source.

_____ b. Should an open occur in any circuit component, current stops flowing to that load but continues flowing through other paths and their loads.

_____ c. When current travels through a resistor, the voltage drop across each resistor is equal to the current divided by the resistance (E = I/R).

_____ d. In a series circuit, the formula ($R_1 = R_t - R_2 - R_3$) may be used to find an individual resistance if the total resistance and the resistances of the other components are known.

Objective 5

Complete the three basic formulas for Watt's law. Write in the blanks the letters, numbers, or words that best complete each formula.

a. P (in watts) = E (volts) x ____________________

b. P (in watts) = ____________________ x R (ohms)

c. P (in watts) = $\dfrac{E^2 \text{ (volts)}}{\rule{3cm}{0.4pt}}$.

Objective 6

State Krichoff's voltage law.

____

____

Objective 7

Select true statements about characteristics of parallel circuits. Write an "X" in the blank before each true statement.

_____ a. Current in a parallel circuit has only one path flow but carries the load across two or more branch circuits; voltage varies throughout the circuit.

_____ b. Voltage drop in a parallel circuit is the drop over the entire circuit; the voltage remains the same throughout the entire system.

_____ c. Total resistance in a parallel circuit is always more than any branch resistance.

_____ d. Reciprocals are any fraction turned upside down.

_____ e. When voltage and the resistance of each branch are known, the branch currents may be calculated by Ohm's law.

_____ f. Should an open occur in any circuit component, the current stops flowing through the circuit and to all loads.

Objective 8

State Krichoff's current law.

____

____

Objective 9

Complete the following statements about characteristics of series-parallel circuits. Write in the blanks the words that best complete each statement.

a. A series-parallel circuit is a circuit used with both series circuits and parallel circuits ____________________.

b. Step 1 in finding resistance in series-parallel circuits is to calculate the total resistance for the circuit and add together the ____________________ in each branch.

c. Step 2 is to ____________________ the circuit to use only one resistance in each branch.

d. The resistance for the circuit may now be calculated by combing the ____________________ resistances.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 8
b. 2
c. 17
d. 13
e. 7
f. 5
g. 1
h. 4
i. 3
j. 16
k. 11
l. 15
m. 19
n. 12
o. 6
p. 9
q. 10
r. 14
s. 18

Objective 2

Answer should include any six of the following:

a. Industrial locations for controls and power
b. Moving of materials and parts
c. Home appliances, radio, television, and stereo equipment
d. Automobile and truck systems
e. Telephone and communications circuits
f. Computers and electronic equipment
g. Airplane control and power systems
h. Medical field
i. Power for electric carts and battery charges

Objective 3

Ohm's law may be used for computing current, resistance, and voltage. Formulas are expressed as:

Current (I) = E/R
Resistance (R) = E/I
Voltage (E) = I x R

Objective 4

a, d

Objective 5

a. I (amperes)
b. I^2 (amperes)
c. R (ohms)

Objective 6

The sum of the individual voltage drops in a series circuit is equal to the applied voltage.

Objective 7

b, d, e

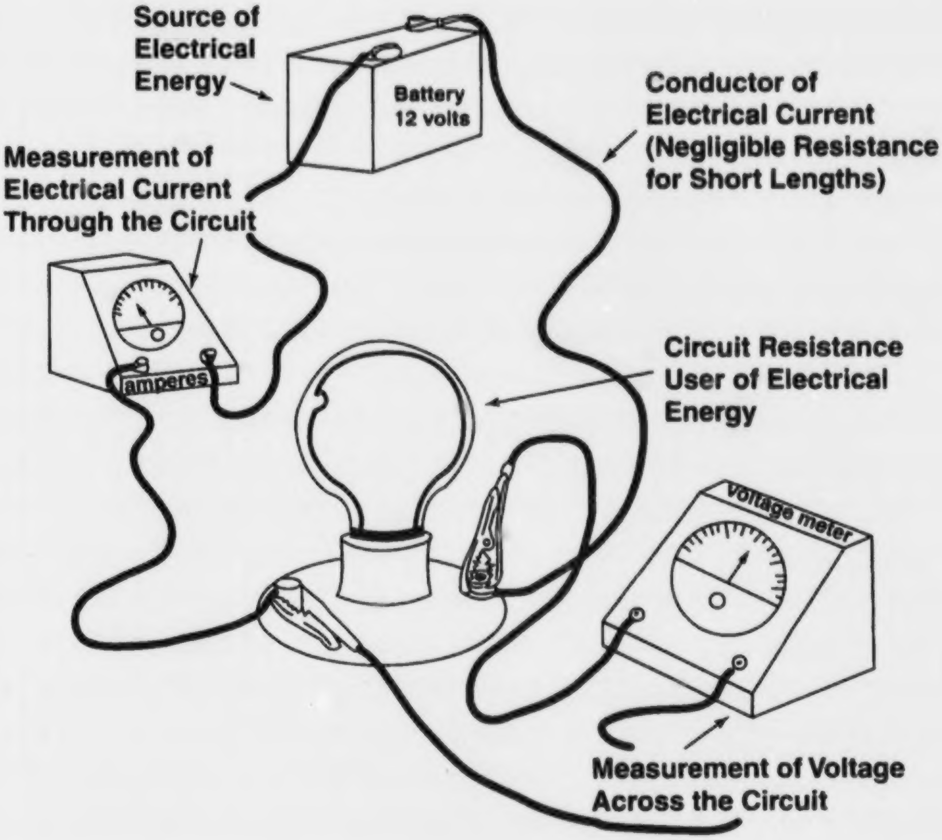
Objective 8

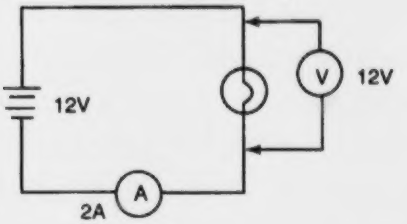
The sum of the currents through the individual branches of a parallel circuit is equal to the total current of the circuit.

Objective 9

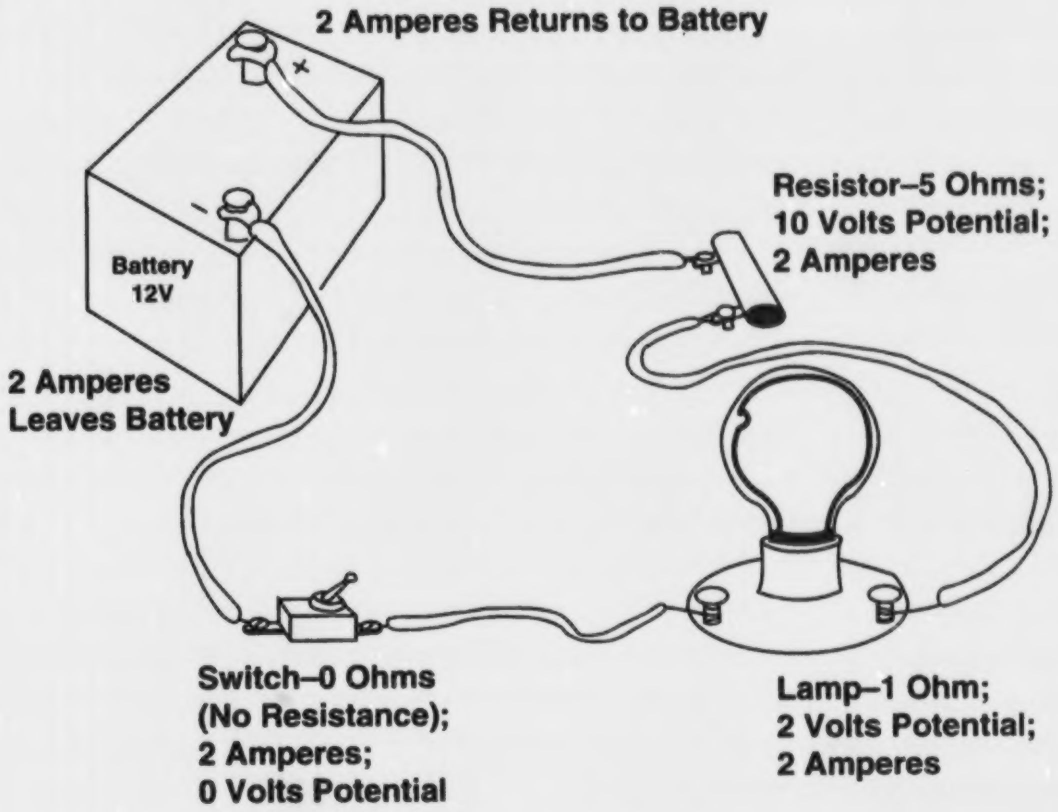
a. Connected
b. Series resistances
c. Redraw
d. Parallel

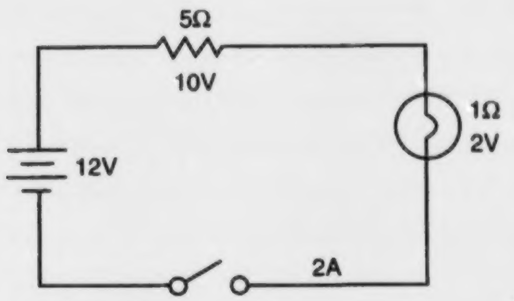
Basic Electrical Circuit


Source of Electrical Energy
Battery 12 volts
Conductor of Electrical Current (Negligible Resistance for Short Lengths)
Measurement of Electrical Current Through the Circuit
amperes
Circuit Resistance User of Electrical Energy
Voltage meter
Measurement of Voltage Across the Circuit


12V
V
12V
A
2A

Series Circuit

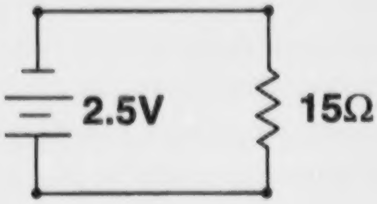

2 Amperes Returns to Battery
+
-
Battery
12V
Resistor–5 Ohms;
10 Volts Potential;
2 Amperes
2 Amperes
Leaves Battery
Switch–0 Ohms
(No Resistance);
2 Amperes;
0 Volts Potential
Lamp–1 Ohm;
2 Volts Potential;
2 Amperes


5Ω
10V
1Ω
2V
12V
2A

Applying Watt's Law

When Voltage and resistance is known:

$\left(P = \frac{E^2}{R}\right)$



$E = 2.5V$

$R = 15\Omega$

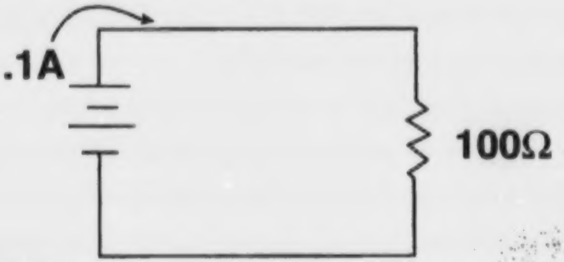
$P = \frac{E^2}{R}$

$P = \frac{(2.5)^2}{15} = \frac{2.5 \times 2.5}{15} = .417\ W$

$P = .417$ Watt

When current and resistance is known:

$P = I^2 \times R$



$R = 100\Omega$

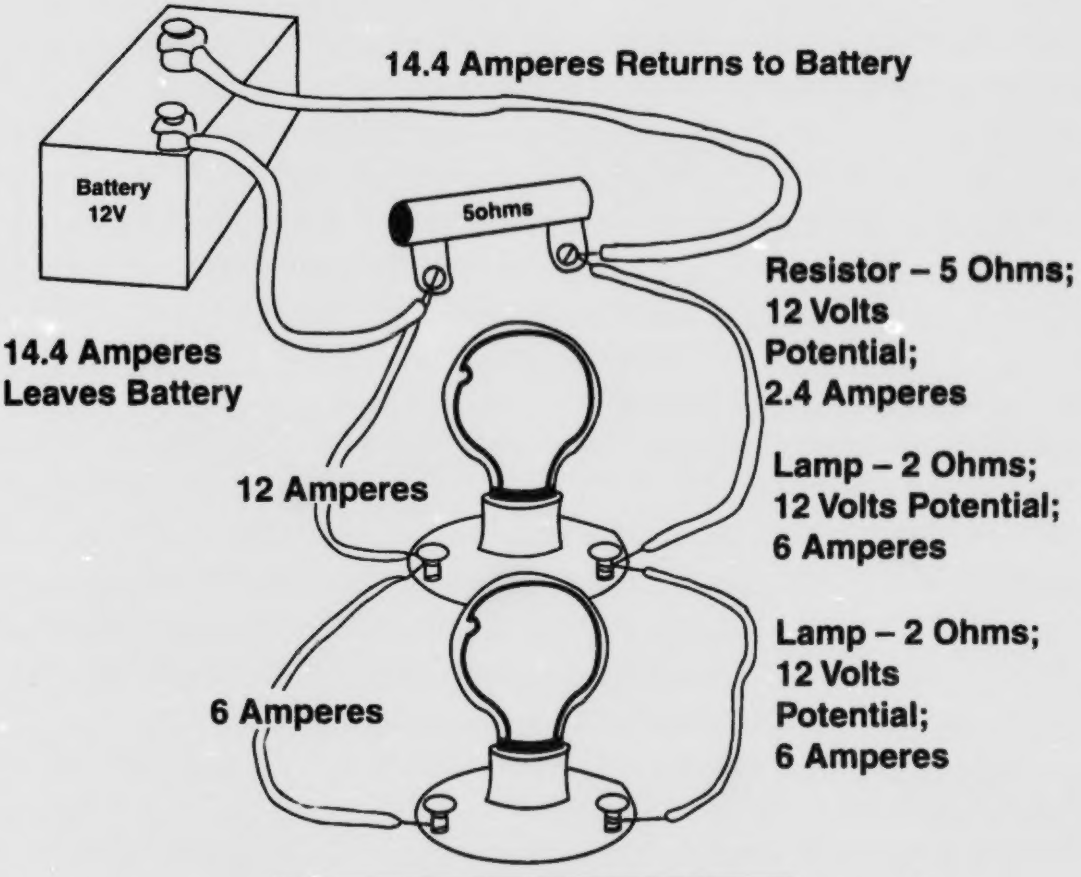
$I = .1A$

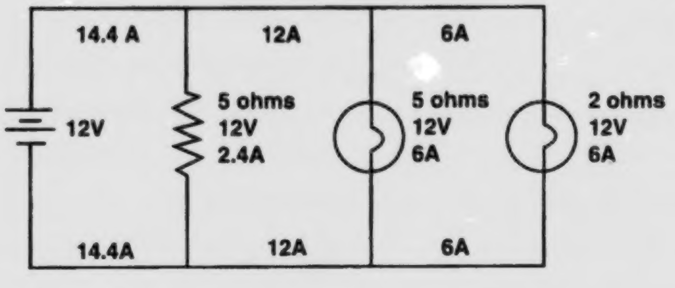
$P = I^2 \times R$

$P = (0.1)^2 \times 100 = (0.1 \times 0.1) \times 100 = 1\ W$

$P = 1$ Watt

Parallel Circuit


14.4 Amperes Returns to Battery
Battery
12V
5ohms
Resistor – 5 Ohms;
12 Volts
Potential;
2.4 Amperes
14.4 Amperes
Leaves Battery
12 Amperes
Lamp – 2 Ohms;
12 Volts Potential;
6 Amperes
6 Amperes
Lamp – 2 Ohms;
12 Volts
Potential;
6 Amperes


14.4 A
12A
6A
12V
5 ohms
12V
2.4A
5 ohms
12V
6A
2 ohms
12V
6A
14.4A
12A
6A

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 11–3

Answers to Assignment Sheets 11–9

Written Test 11–11

Answers to Written Test 11–19

Teacher Supplement

1—Facts About Producing Electricity 11–21

Transparency Masters

1—Induced Current 11–23
2—Induction 11–25
3—Power in RL Circuits 11–27
4—Classes of Transformers 11–29
5—Impedance Relationships in an RC Circuit 11–31
6—Electric Field Effect on Dielectrics 11–33
7—Capacitor Construction 11–35
8—Plate Area 11–37
9—Plate Distance 11–39
10—Effect of the Dielectric 11–41
11—AC Switching Circuits 11–43
12—AC Switching Cirucits (continued) 11–45

Student Page

Student Components

Learning Activities Sheet 11–3

Objective Sheet 11–7

Information Sheet 11–9

* Focus Assignment

List Facts About Producing Electricity 33

* Assignment Sheets

1—Solve RC and RL Circuit Problems 35
2—Solve Power Factor Problems 37

Unit Contents

3—Draw a Diagram of a Single-Pole Switch on a Light 39
4—Draw a Diagram of Two-Three-Way Switches on a Light 41
5—Draw a Diagram of Two Three-Way Switches and a Four-Way Switch on a Light 43

* Job Sheets

1—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Switch Box 45
2—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box .. 55
3—Wire a Three-Way Switching Situation with the Supply Line Entering a Single Lighting Outlet 61
4—Wire a Four-Way Switching Situation with the Supply Line Entering the Lighting Outlet Box 69

* Focus Assignment, Assignment Sheets, and Job Sheets are located in Student Workbook 2.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM1—Induced Current (Objective 3)
TM2—Induction (Objective 4)
TM3—Power in RL Circuits (Objective 5)
TM4—Classes of Transformers (Objective 8)
TM5—Impedance Relationships in an RC Circuit (Objective 15)
TM6—Electric Filed Effect on Dielectrics (Objective 15)
TM7—Capacitor Construction (Objective 15)
TM8—Plate Area (Objective 15)
TM9—Plate Distance (Objective 15)
TM10—Effect of the Dielectric (Objective 15)
TM11—AC Switching Circuits (Objective 18)
TM12—AC Switching Circuits (continued) (Objective 18)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students view an AC waveform on an oscilloscope.
- Take field trip to a house under construction, and view basic switching devices.
- Invite a representative from a local supply house to give a demonstration on switching.
- Show students how to solve RC and RL circuit problems. Discuss calculations for Assignment Sheet 1 in class.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

Suggested Activities

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Adams, James E. and Gorden Rockmaker. *Industrial Electricity Principles and Practices*, Third Edition. New York: McGraw-Hill Book Company, 1985.

- *Basic Electricity Review*. Rockville, MD: NUS Training Corporation, a Halliburton Company, 1985.

Suggested Activities

- Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.
- Voderstrasse, Ron. *General Electronics Technician*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1986.
- *National Electrical Code, 2002*. Quincy, MA: National Fire Protection Association, 2001.
- *National Electrical Code, 1999*. Quincy, MA: National Fire Protection Agency, 1998.

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes*. Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC

- *NEC 2002 Handbook*. Quincy, MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics

  The publication(s) listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org

- Herman, Stephen L. *Electrician's Technical Reference: Electrical Theory and Calculations*. Delmar Publishers, Inc. 2002.
- Herman, Stephen L. *Electrician's Technical Reference: Transformers*. Delmar Publishers, Inc. 1999.
- Miller, Chris. *Illustrated Guide to the National Electrical Code*, 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type of occupancy, and contains 60 illustrations.

- O'Riley, Ronald. *Electrical Grounding*, 6th ed. Delmar Publishers, Inc. 2002.

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code,* 6th ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.

Electronic Media

- Electrical Theory – AC Video Set (set of four)

  Video 1: Alternating Current
  Video 2: Inductance
  Video 3: Capacitors
  Video 4: Series Circuits

  Available on video or CD-ROM, this set can be purchased online at www.delmar.com or by calling 1-800-477-3692

Answers to Assignment Sheets

Assignment Sheet 1

Solve Power Factor Problems

a. 8.85mΩ
b. $X_c = 13.2\Omega$; $I = 15.75\text{A}$
c. 131.88Ω
d. $X_L = 188.4\Omega$; $I = 0.53\text{A}$
e. $X_L = 226.08\Omega$; $Z = 2{,}211\Omega$

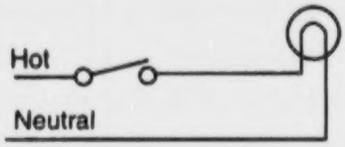
Assignment Sheet 2

Solve RC and RL Circuit Problems

a. 0.70 or 70%
b. 0.76 or 76%
c. 0.83 or 83%
d. 0.83 or 83%
e. 0.85 or 85%
f. 0.67 or 67%
g. 0.96 or 96 %
h. 0.88 or 88%

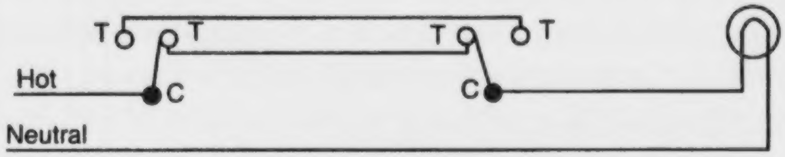
Assignment Sheet 3

Draw a diagram of a single-pole switch on a light



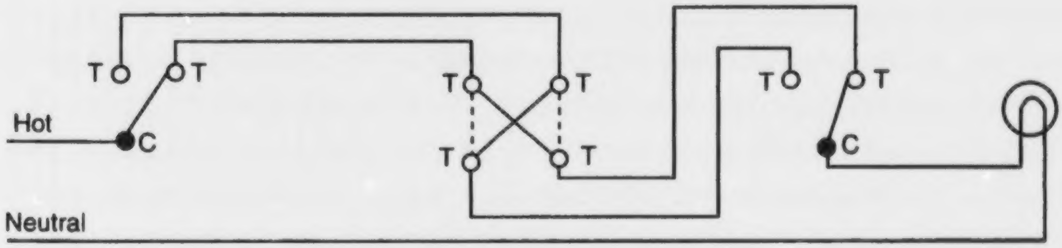
Assignment Sheet 4

Draw a diagram of two three-way switches on a light



Assignment Sheet 5

Draw a diagram of two three-way switches and a four-way switch on a light



Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match the terms related to AC Circuits with their correct definitions. Write the correct numbers in the blanks.

1. Apparent power
2. Autotransformer
3. Connections
4. Dielectric materials
5. Henry
6. Opposition
7. Three phase
8. Primary
9. Secondary
10. Single phase
11. True power
12. Waveform
13. Windings

_____ a. The shape of a wave as a function of time, distance, and amplitude

_____ b. One power source

_____ c. Transformer with a single winding

_____ d. A resistance to current flow

_____ e. Termination points where conductors are joined together

_____ f. The power that a device is actually using

_____ g. Amount of inductance into a conductor when the current changes at the rate of 1 ampere per second

_____ h. Where voltage enters a transformer

_____ i. Conductors coiled around a metal core in a transformer or motor

_____ j. Insulating materials capable of accumulating an electrical charge

_____ k. Where voltage leaves a transformer

_____ l. Term used to describe the power that "appears" to be consumed in an RC circuit when the power formula VA = IE is applied to the circuit

_____ m. Three separate power sources

Written Test

Objective 2

Select true statements about the principles of AC theory by placing an "X" in the blanks next to the true statements.

_____ a. AC current flows in two directions; it flows in one direction, stops, and then flows in the opposite direction.

_____ b. There are two basic types of waveforms: square wave and sawtooth wave.

_____ c. Sine waves are measured peak-to-peak in AC voltage or amperes.

_____ d. Peak-to-peak current and voltages occur three times in a cycle: one in the positive direction, one in neutral, and one in the negative direction.

_____ e. The rms (root-mean-square) or effective value of the sine wave is .007 times peak value.

_____ f. Electromotive force (emf) causes current to flow through a device; this is referred to in sine waves as V.

Objective 3

Complete statements related to the principles of induction by filling in the blanks with the word(s) that best completes each statement.

a. ____________________ induction occurs when a magnet is placed in close proximity to a ferromagnetic material causing the material to also become magnetized.

b. ____________________ induction is the action that causes electrons to flow in a conductor when the conductor cuts the lines of force in a magnetic field.

c. The amount of current induced into the conductor is determined by four factors (Faraday's law):

(1) _______________ of the magnetic field

(2) _______________ of the conductor with respect to the field

(3) _______________ at which the conductor cuts the field

(4) _______________ of the conductor in the field

d. Lenz's law states that the direction of the induced current must be such that its own magnetic field will ____________________ the action that produced the induced current.

Objective 4

Complete statements about inductance characteristics by filling in the blanks with the word(s) that best completes each statement.

a. ______________________ is the physical property of a circuit or device that indicates an ability to oppose a change in current.

b. Inductance may be defined as the ability to induce an EMF into a conductor when there is a change in________________ ________________.

c. The symbol for inductance is the letter ______________________ .

d. The unit of measurement for inductance is the ____________________.

e. A Henry is the amount of inductance that induces an EMF of 1 volt into a conductor when the ______________________ changes at the rate of 1 ampere per second.

f. The Henry is expressed symbolically with the letter ________________.

Objective 5

Select true statements about factors affecting inductors by placing an "X" in the blanks next to the true statements.

_____ a. An inductor is a physical device consisting of a coil of wire usually wound on a core.

_____ b. The inductance of a coil varies as the square of the number of turns.

_____ c. Inductance of a coil may be decreased dramatically by winding the coil on a core of material that has a high permeability.

_____ d. Inductance varies inversely with the winding of the coil.

Objective 6

Select true statements about power characteristics in inductive circuits by placing an "X" in the blanks next to the true statements.

_____ a. No power is dissipated in a pure inductance.

_____ b. Power dissipation in an RL circuit occurs in the resistance within the circuit.

_____ c. Since power is dissipated only in the resistance, it may be calculated using the standard power formulas.

Written Test

Objective 7

Complete statements about transformer characteristics by filling in the blanks with the word(s) that best completes each statement.

a. The transformer is one use of the ____________________ process.

b. Different electrical devices require ____________________ operating ____________________. Transformers change these voltages to meet a specific need.

c. Transformers have three basic parts: a primary conductor, a secondary conductor, and a ____________________.

d. When the windings on the primary side are decreased and the windings on the secondary side are increased, this is called a ____________________ transformer.

e. When the windings on the primary side are increased and the windings on the secondary side decreased, this is called a ____________________ transformer.

f. ____________________ have a single winding that acts as a primary and secondary.

Objective 8

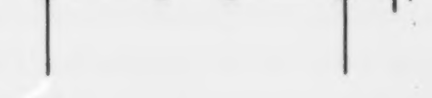
List the two classes of transformers.

a. ____________________

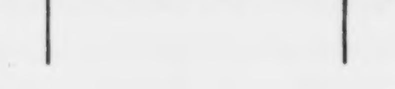
b. ____________________

Objective 9

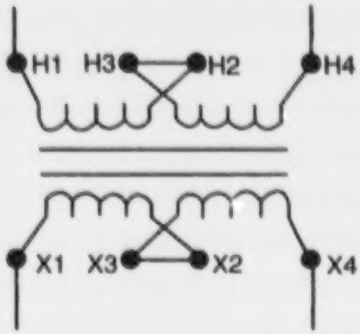
Identify single-phase transformer connections. Write the correct names in the blanks.



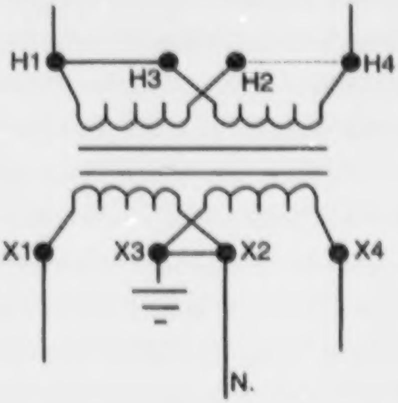
a. ____________________



b. ____________________

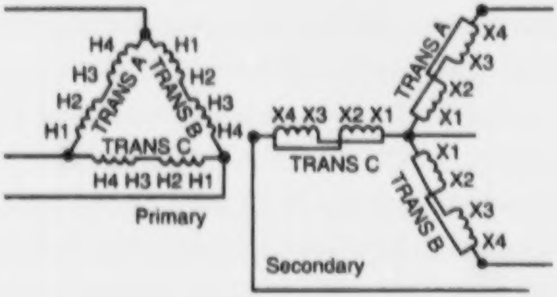

H1
H3
H2
H4
X1
X3
X2
X4

c. ______________________

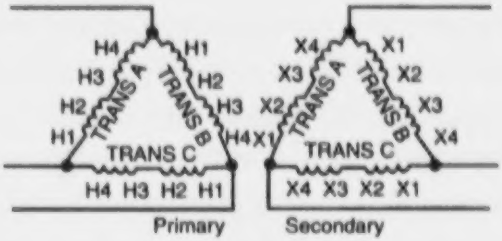

H1
H3
H2
H4
X1
X3
X2
X4
N.

d. ______________________

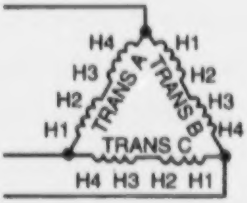
Objective 10 Identify other transformer connections found in electrical trades. Write the correct names in the blanks.


H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
X4 X3 X2 X1
TRANS C
TRANS A
X4
X3
X2
X1
X1
X2
X3
X4
TRANS B
Secondary

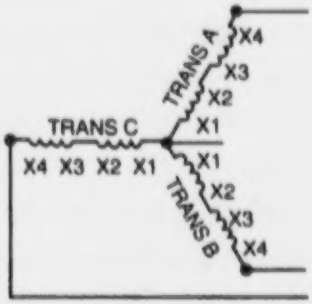
a. ______________________


H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
X4
X1
X3
X2
X2
X3
X1
X4
TRANS A
TRANS B
TRANS C
X4 X3 X2 X1
Secondary

b. ______________________


H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1

c. ______________________


TRANS A
X4
X3
X2
X1
TRANS C
X4 X3 X2 X1
X1
X2
X3
X4
TRANS B

d. ______________________

Written Test

Objective 11

Complete the following statements about power in three-phase circuits. Circle the word that best completes each statement.

a. (**Wye, Delta**)—Voltage across each load member is full-line voltage; amperage in each member is $\sqrt{3}$ x line amps or 1.732 x amps .

b. (**Delta, Wye**)—Amperage in each member is full-line amperage; voltage across each member is $\sqrt{3}$ x line volts or 1.732 x volts.

Objective 12

Select true statements about testing for polarity by placing an "X" in the blanks next to the true statements.

_____ a. When testing a transformer for polarity, there are two kinds of windings: additives and subtractives.

_____ b. When testing a transformer for polarity, connect one test lead to the high voltage side and the other test lead to the low voltage tap directly under the high voltage tap.

_____ c. If the meter reads the incoming voltage, it is a subtractive.

_____ d. If the meter reads less than the incoming voltage, it is an additive.

_____ e. When finding the taps for an additive transformer, the taps are usually opposite each other.

_____ f. When finding the taps for a subtractive transformer the taps are usually directly under each other.

Objective 13

Complete statements about capacitance characteristics by filling in the blanks with the word(s) that best completes each statement.

a. The property of a circuit or device that enables it to store electrical energy with an electrostatic field is called ____________________.

b. A device that is made to have specific value of capacitance is called a ____________________.

c. A capacitor is a device constructed of two metal plates separated by a ____________________.

d. Capacitance of a capacitor is determined by three factors:

  (1) The ________________ of the metal plates.

  (2) The ________________ between the plates.

  (3) The type or nature of the ________________.

e. The unit of capacitance is the ____________________.

f. One ____________________ is the amount of capacitance that will store a charge of one coulomb when 1 volt of EMF is applied.

Objective 14

Select true statements about types, ratings, and common defects of capacitors by placing an "X" in the blanks next to the true statements.

_____ a. There are two basic types of capacitors: fixed value capacitors and variable capacitors.

_____ b. Capacitors are classified by the type of dielectric used, such as mica, ceramic, paper, and mylar.

_____ c. Capacitors may be an electrolytic type.

_____ d. Capacitors are rated according to value of capacitance.

_____ e. Defects in capacitors are related to four common failures.

Objective 15

Complete the following statements about capacitive AC circuits. Circle the word that best completes each statement.

a. When voltage is applied to a capacitor in an AC circuit, it will appear that electrons are (**flowing, static**) in the circuit.

b. Electrons will not travel through the (**voltage field, dielectric**) of a capacitor.

c. As the applied (**voltage, capacitance**) increases and decreases in amplitude, the capacitor will charge and discharge.

d. The movement of electrons from one (**frequency, plate**) to another represents current flow.

e. Current and voltage do not flow in phase in a capacitive circuit: when the current is at its maximum, the voltage is at 0, thus the relationship is (**180, 90**) degrees out of phase.

f. The current (**leads, lags**) the applied voltage in a capacitive circuit.

g. After a capacitor is initially charged by an AC voltage, the voltage stored on the plates opposes any change in the applied voltage. This opposition to change in voltage is known as capacitive (**inductance, reactance**).

Objective 16

Complete the following statements about inductive AC circuits. Circle the word that best completes each statement.

a. In AC circuits, inductors offer (**opposition, assistance**) to current flow.

b. As AC voltage is applied to an inductor or inductive circuit, a magnetic field (**contracts, expands**) and collapses around the inductor.

c. This magnetic field induces a voltage in the windings of the inductor. This is called counter-electromotive force (CEMF). CEMF is always (**more, less**) than the applied EMF.

d. CEMF is an effective means of controlling current flow because it is (**90, 180**) degrees out of phase of the applied voltage and opposes the applied voltage.

e. Opposition to current flow in inductive AC circuits is known as inductive (**reactance, Impedance**).

f. The combination of both resistance and reactance is called (**inductance, impedance**).

g. The most common inductive circuit consists of an inductor connected in series with a resistor. This is called an (**RC, RL**) circuit.

Objective 17

Select true statements about power characteristics in AC circuits by placing an "X" in the blanks next to the true statements.

_____ a. In an AC circuit, voltage and current are always in phase.

_____ b. The power or product of voltage and current must be multiplied by a power factor to determine the true power.

_____ c. By using a meter one can determine the true power in a circuit.

Objective 18

List three basic switching circuits used in electricity.

a. ____

b. ____

c. ____

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 12
b. 10
c. 2
d. 6
e. 3
f. 11
g. 5
h. 8
i. 13
j. 4
k. 9
l. 1
m. 7

Objective 2

a, c, f

Objective 3

a. Magnetic
b. Electromagnetic
c. (1) Strength
   (2) Speed
   (3) Angle
   (4) Length
d. Oppose

Objective 4

a. Inductance
b. Current flow
c. L
d. Henry
e. Current
f. H

Objective 5

a, b

Objective 6

a, b, c

Objective 7

a. Induction
b. Different, voltages
c. Metal core
d. Step-up
e. Step-down
f. Autotransformers

Objective 8

a. Single-phase
b. Three-phase

Objective 9

a. Parallel primary, parallel secondary
b. Series primary, parallel secondary
c. Series primary, series secondary
d. Parallel primary, series secondary

Answers to Written Test

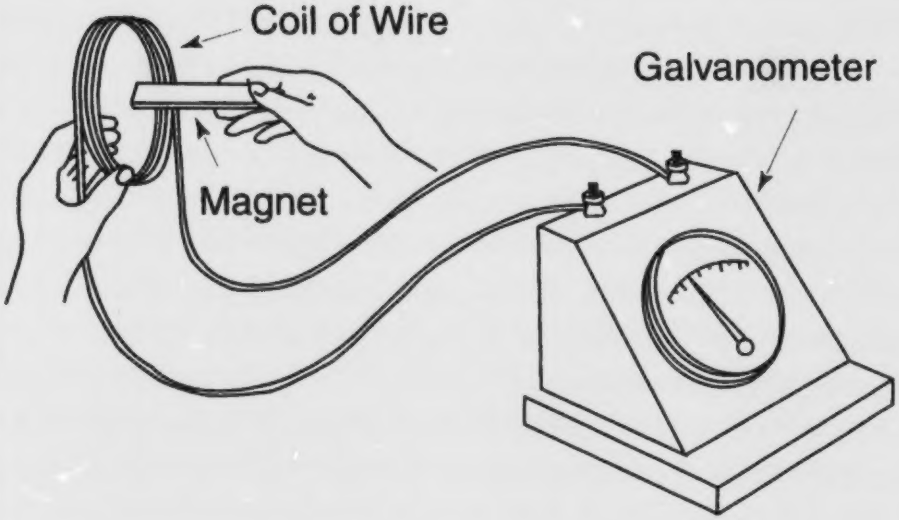
Objective 10	a. Delta-wye b. Delta-delta c. Delta d. Wye
Objective 11	a. Delta b. Wye
Objective 12	a, b
Objective 13	a. Capacitance b. Capacitor c. Dielectric d. (1) Area (2) Spacing (3) Dielectric e. Farad f. Farad
Objective 14	a, b, c, d, e
Objective 15	a. Flowing b. Dielectric c. Voltage d. Plate e. 90 f. Leads g. Reactance
Objective 16	a. Opposition b. Expands c. Less d. 180 e. Reactance f. Impedance g. RL
Objective 17	b, c
Objective 18	a. Single-pole switch b. Three-way switch c. Four-way switch

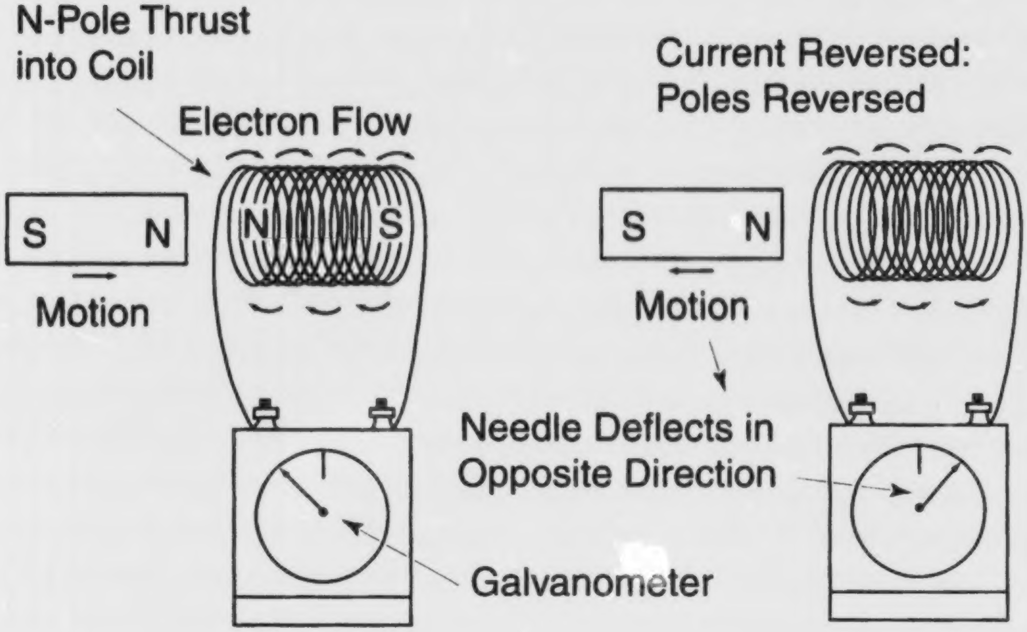
Teacher Supplement 1—Facts About Producing Electricity

- This supplement is intended to be used in conjunction with the Focus Assignment.

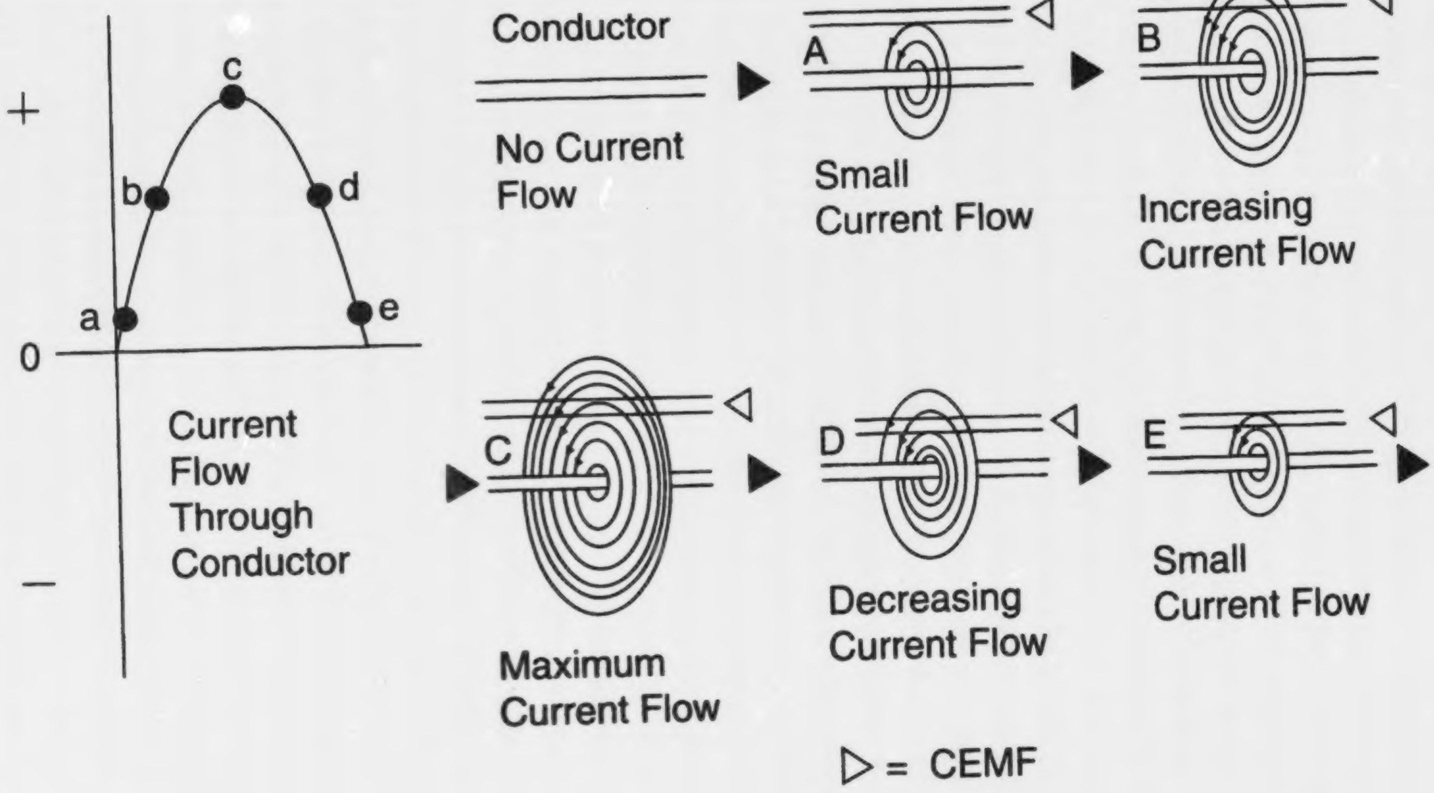
Process	Advantages	Disadvantages
Hydroelectric	• Cheap power supply • Reusable • Readily available	• Subject to flood and drought
Coal	• Can be located anywhere • Easy to operate	• Non-renewable fuel source • Environmental problems
Nuclear	• Efficient	• Potential hazardous environmental problems
Solar (Photovoltaic Systems)	• Non-consumable energy • Clean • Few moving parts	• Dependent on sunlight hours • Expensive • Must convert DC to AC voltage
Wind	• Non-consumable energy source • Clean	• Dependent on wind availability • Not reliable

Induced Current


Coil of Wire
Galvanometer
Magnet


N-Pole Thrust into Coil
Electron Flow
S
N
N
S
Motion
Galvanometer
Current Reversed: Poles Reversed
S
N
Motion
Needle Deflects in Opposite Direction

Induction



Current Flow Through Conductor

Conductor

No Current Flow

Small Current Flow

Increasing Current Flow

Maximum Current Flow

Decreasing Current Flow

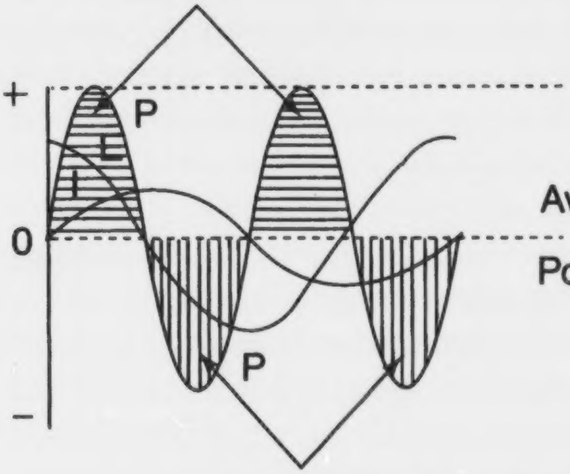
Small Current Flow

▷ = CEMF

Relationship of magnetic field around a wire to current flowing through the wire

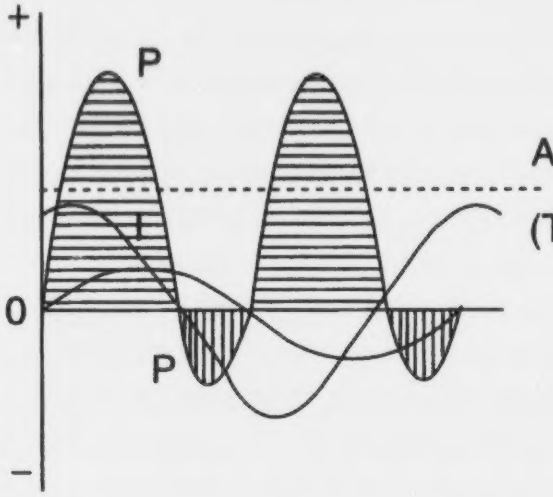
Power in RL Circuits

Power Consumed by the Inductor



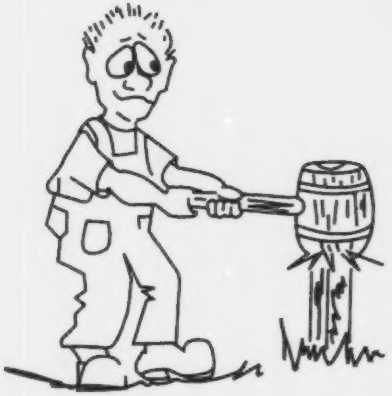
Average Power - Zero

Power Returned to the Circuit by the Inductor

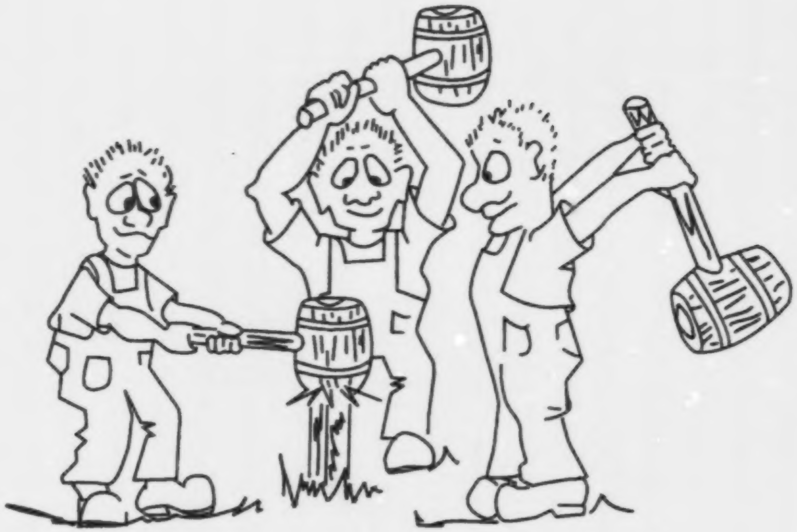


Average (True) Power

Classes of Transformers

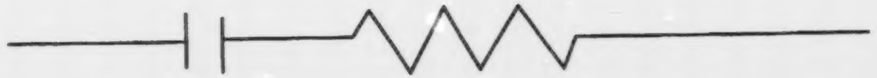


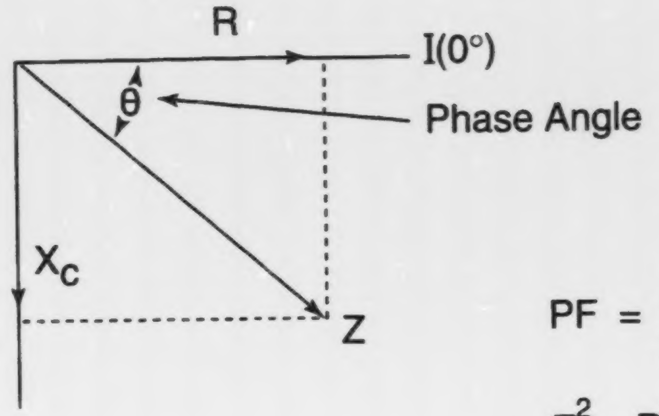
Single Phase



Three Phase

Impedance Relationships in an RC Circuit

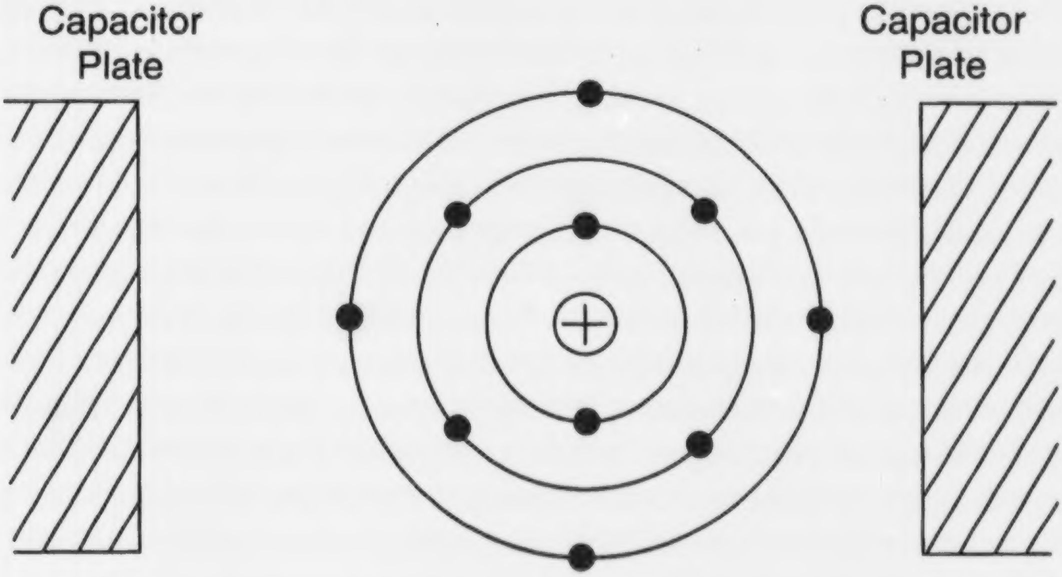



R
I(0°)
θ
Phase Angle
X_C
Z

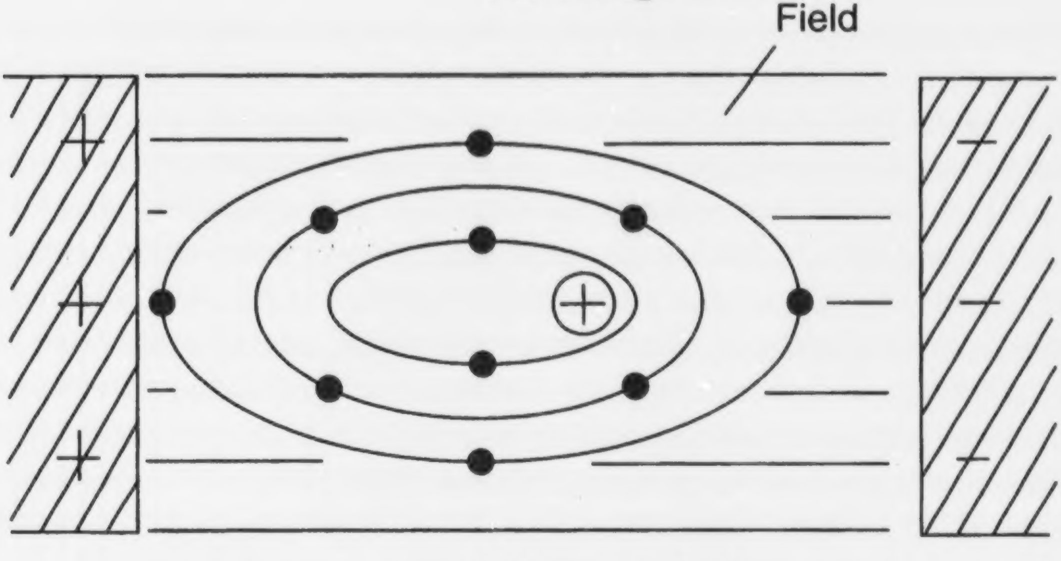
$PF = \frac{R}{Z}$

$Z^2 = R^2 + X_C{}^2$

Electric Field Effect on Dielectrics


Capacitor Plate
Capacitor Plate

No Voltage



Voltage Applied

Capacitor Construction

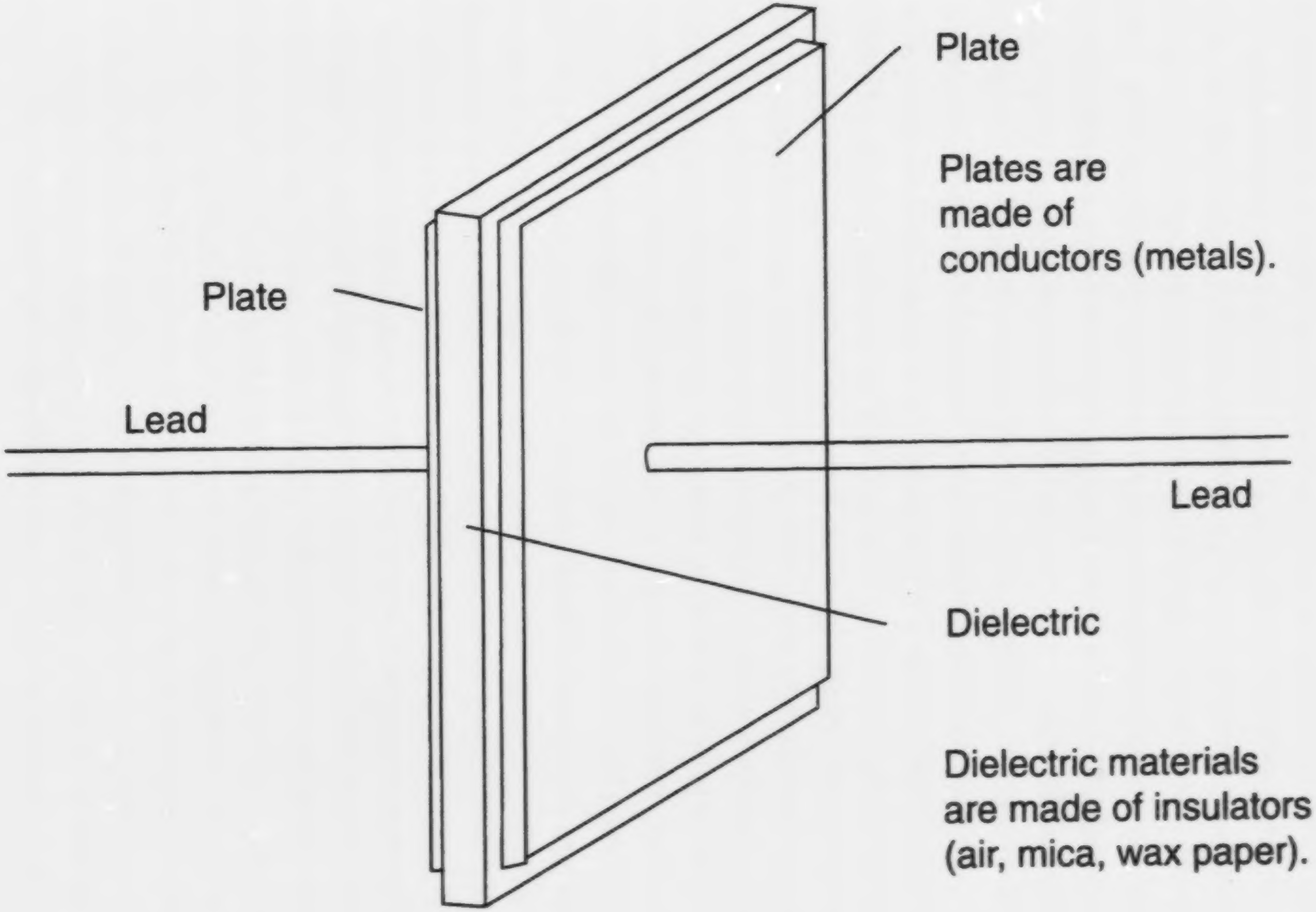
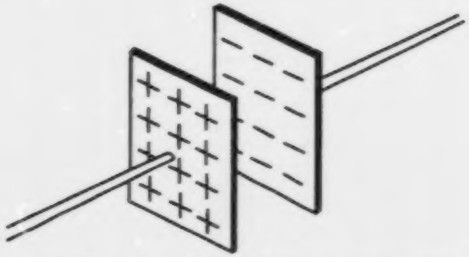


Plate
Plate
Lead
Lead
Dielectric

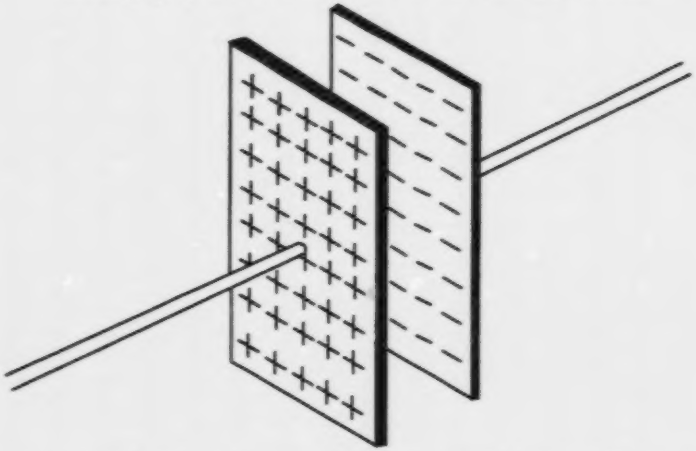
Plates are
made of
conductors (metals).

Dielectric materials
are made of insulators
(air, mica, wax paper).

Plate Area

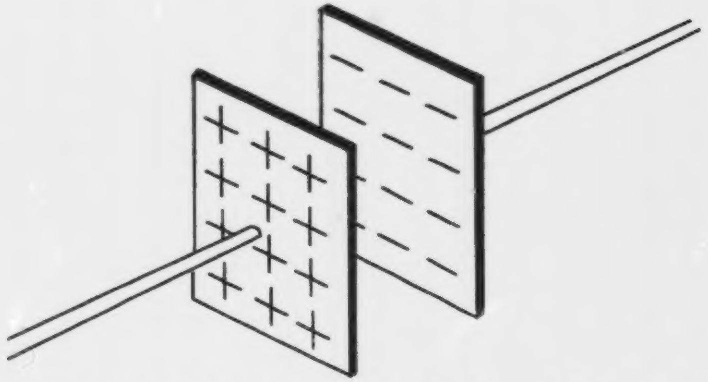


Larger plates hold more electrons.

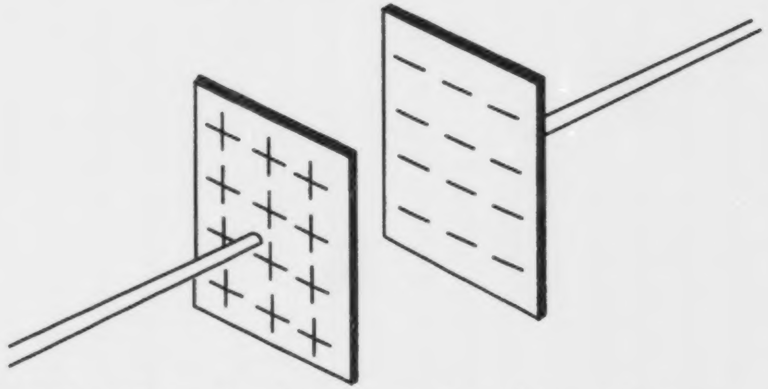


Increased plate area increases capacitance.

Plate Distance



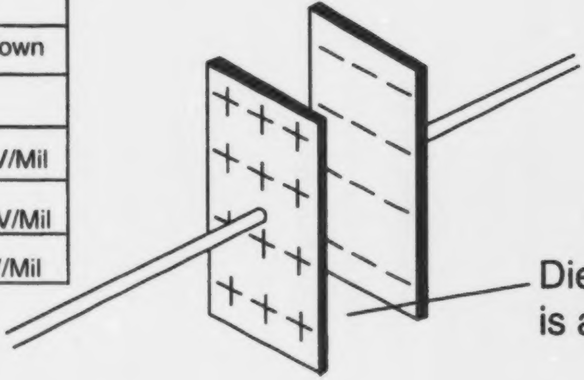
The distance between two charges determines their effect on one another.



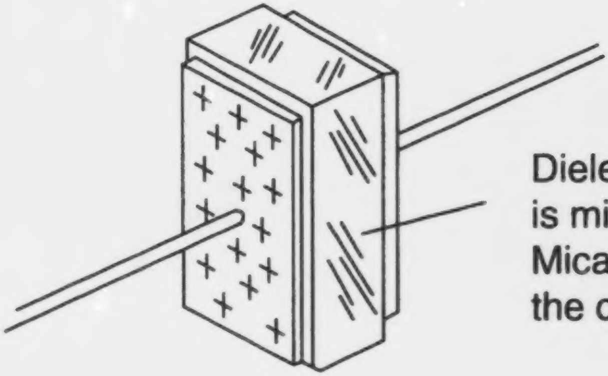
Increasing the distance between the plates decreases capacitance.

Effect of the Dielectric

Typical Dielectric		
Type	Constant	Breakdown
Air	1.0	
Mica	5.4	5000V/Mil
Teflon	2.1	1500V/Mil
Paper	3.0	200V/Mil



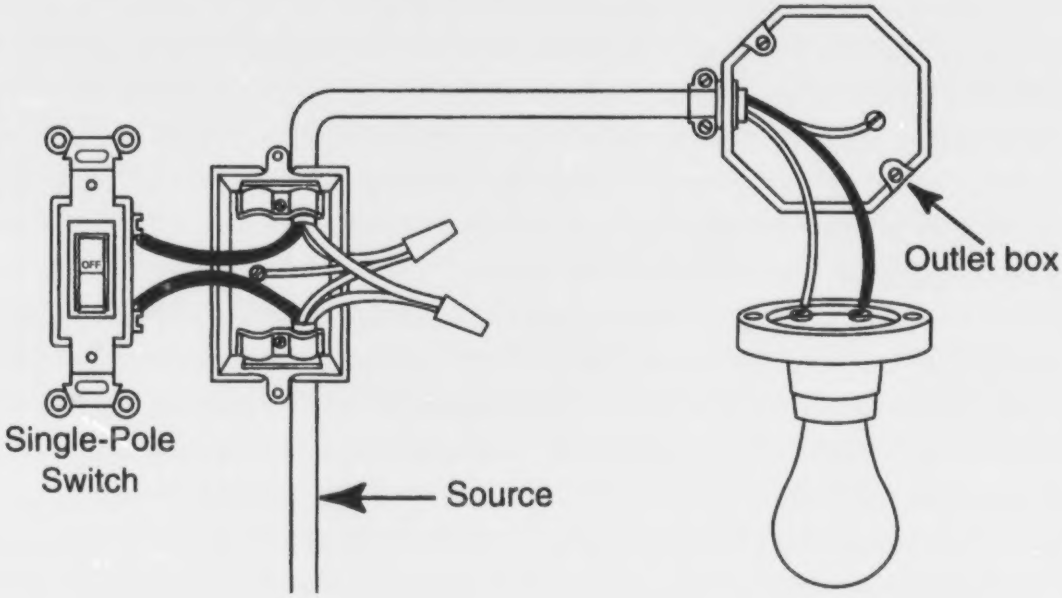
Dielectrical material
is air.



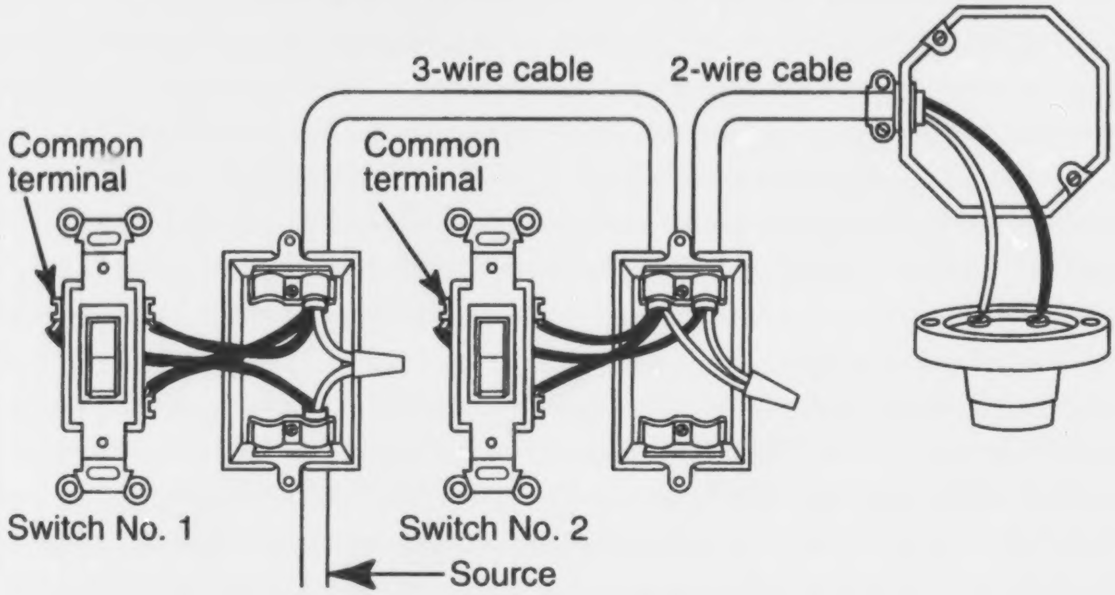
Dielectrical material
is mica.
Mica dielectric increases
the capacitance.

Changing the dielectric material changes the capacitance.

AC Switching Circuits

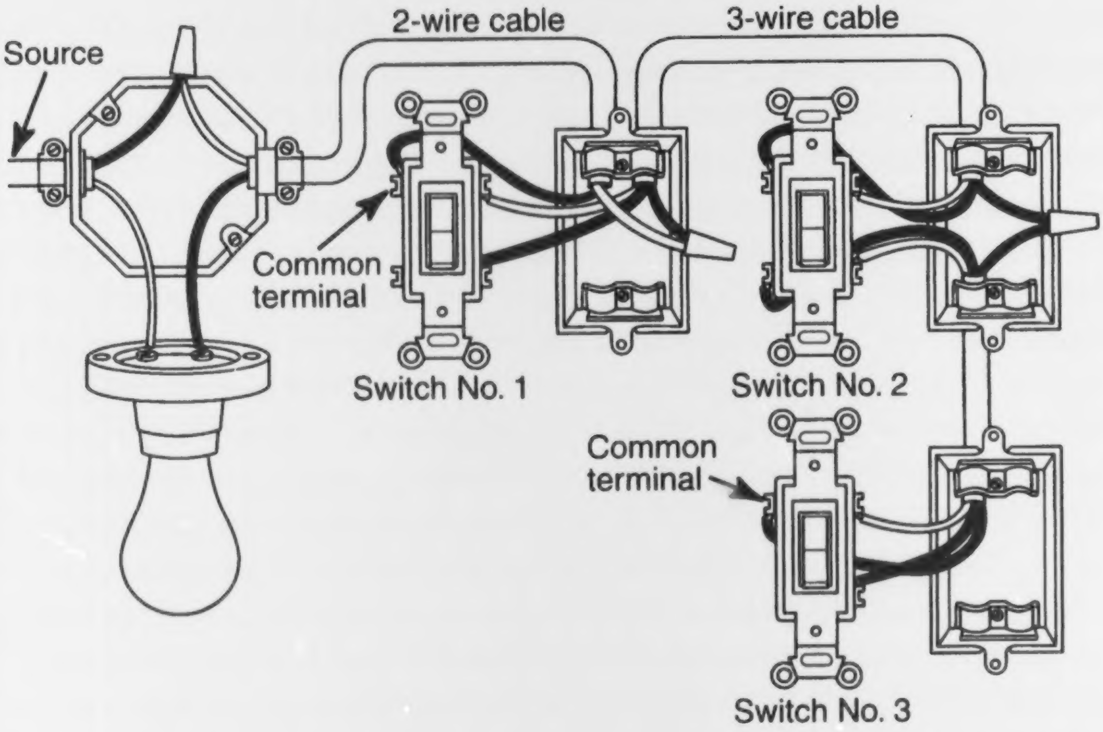

Outlet box
OFF
Single-Pole Switch
Source

Single-Pole Switch


3-wire cable
2-wire cable
Common terminal
Common terminal
Switch No. 1
Switch No. 2
Source

Three-Way Switch

AC Switching Circuits (continued)


2-wire cable
3-wire cable
Source
Common terminal
Switch No. 1
Switch No. 2
Common terminal
Switch No. 3

Four-Way Switch

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 12–3

Answers to Assignment Sheets 12–9

Written Test 12–17

Answers to Written Test 12–25

Teacher Supplement

1—Various Environments and Structures Requiring Electrical Wiring Installations 12–27

Transparency Masters

1—Nonmetallic Sheathed Cable 12–29
2—Nonmetallic Sheathed Cable (continued) 12–31
3—Romex Connectors 12–33
4—Rigid Metal Conduit 12–35
5—Rigid Metal Conduit Bodies 12–37
6—Rigid Metal Conduit Bodies (continued) 12–39
7—Electrical Metallic Tubing 12–41
8—Conduit Fittings 12–43
9—Set Screw Fittings 12–45
10—Compression or Raintight Fittings 12–47
11—Locknuts and Bushings 12–49
12—Grounding Bushing 12–51
13—Meyers Hub 12–53
14—Supports 12–55
15—Three Common Types of Straps 12–57
16—Unistrut and Unistrut Clamps 12–59
17—Nipples 12–61
18—Flexible Metal Conduit 12–63
19—Flexible Metal Conduit Connectors 12–65
20—Liquidtight Flexible Metal Conduit Connectors 12–67
21—Liquidtight Flexible Metal Conduit Connectors (continued) . . . 12–69
22—Device Box and Surface Raceway 12–71
23—Cable Trays 12–73
24—Rigid Nonmetallic Conduit (PVC) 12–75
25—PVC Fittings 12–77
26—Metal Clad (MC) Cable 12–79
27—Metal Clad Cable Connector 12–81

Unit Contents

Student Components

Student Page

Learning Activities Sheet 12–3

Objective Sheet 12–5

Information Sheet 12–7

* Focus Assignment

Identify Environments and Structures Requiring
Electrical Wiring Installations 77

* Assignment Sheet

1—Reference The *National Electrical Code* to
Identify Uses of Wiring Methods 79

* Job Sheets

1—Install a Set-Screw Conduit Fitting 85
2—Install a Compression-Type Conduit Fitting 87
3—Prepare MC Cable for Termination 91
4—Install a Connector onto Liquidtight Flexible
Metal Conduit 99
5—Install a Connector onto Rigid Nonmetallic Conduit 103

* Focus Assignment, Assignment Sheet and Job Sheets are located in Student Workbook 2

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM1—Nonmetallic Sheathed Cable (Objective 2)
TM2—Nonmetallic Sheathed Cable (continued) (Objective 2)
TM3—Romex Connectors (Objective 2)
TM4—Rigid Metal Conduit (Objective 2)
TM5—Rigid Metal Conduit Bodies (Objective 2)
TM6—Rigid Metal Conduit Bodies (continued) (Objective 2)
TM7—Electrical Metallic Tubing (Objective 2)
TM8—Conduit Fittings (Objective 2)
TM9—Set Screw Fittings (Objective 2)
TM10—Compression or Raintight Fittings (Objective 2)
TM11—Locknuts and Bushings (Objective 2)
TM12—Grounding Bushing (Objective 2)
TM13—Meyers Hub (Objective 2)
TM14—Supports (Objective 2)
TM15—Three Common Types of Straps (Objective 2)
TM16—Unistrut and Unistrut Clamps (Objective 2)
TM17—Nipples (Objective 2)
TM18—Flexible Metal Conduit (Objective 2)
TM19—Flexible Metal Conduit Connectors (Objective 2)
TM20—Liquidtight Flexible Metal Conduit Connectors (Objective 2)

TM21—Liquid Tight Flexible Metal Conduit Connectors (continued) (Objective 2)
TM22—Device Box and Surface Raceway (Objective 2)
TM23—Cable Trays (Objective 2)
TM24—Rigid Nonmetallic Conduit (PVC) (Objective 2)
TM25—PVC Fittings (Objective 2)
TM26—Metal Clad (MC) Cable (Objective 2)
TM27—Metal Clad Cable Connector (Objective 2)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Take students on a field trip to a local electrical supply house.
- Invite a local inspector to talk to the class about various wiring methods.
- Have a journeyman demonstrate wiring methods.
- Have students report on articles dealing with wiring methods.
- Invite manufacturer representative to perform presentations on their materials.
- Have students perform an inventory of wiring materials in your classroom storage areas.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

Suggested Activities

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code, 1993*. Quincy, MA: National Fire Protection Association, 1992.
- Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-American Vocational Curriculum Consortium, 1983.
- *National Electrical Code, 2002*. Quincy, MA: National Fire Protection Association, 2001.
- *National Electrical Code, 1999*. Quincy, MA: National Fire Protection Association, 1998.

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes*. Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view fo the most important changes in the 2002 NEC

- *NEC 2002 Handbook*. Quincy, MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics

  The publication(s) listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org

- Early, Mark W., et al. *Illustrated Changes in the National Electrical Code*. Delmar Publishers, Inc. 2002.

  Provides a detailed view fo the most important changes in the 2002 NEC

- Loyd, Richard. *Electrician's Technical Reference: Wiring Methods.* Delmar Publishers, Inc. 1999.
- Miller, Chris. *Illustrated Guide to the National Electrical Code,* 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type or occupancy, and contains 600 illustrations
- Mullin, Ray. *Electrical Wiring Residential,* 14th ed. Delmar Publishers, Inc. 2002.
- Mullin, Ray. *House Wiring with the National Electrical Code,* 11th ed. Delmar Publishers, Inc. 1999.

  Covers everyting from lighting branch circuits, to small and large appliance branch circuits.
- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code,* 6th ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied
- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.

Electronic Media

- Software and Videos. AAVIM, 220 Smithonia Road, Winterville, GA 30683. Phone (800) 228-4689. www.aavim.com
- AFC Cable Systems. Information on types of cable at www.afcweb.com
- Electrical search engine to find information on products, publication, service, codes, etc. at www.electricalsearch.com
- Electrical search engine on a wide variety of subjects at www.electriciansweb.com

Answers to Assignment Sheets

Assignment Sheet 1

Reference the *National Electrical Code* to Identify Uses of Wiring Methods

a. 348.10. Uses Permitted

Flexible metal conduit shall be permitted to be used in exposed and concealed locations.

348.12. Uses Not Permitted

Flexible metal conduit shall not be used in the following:

(1) In wet locations unless the conductors are approved for the specific conditions and the installation is such that liquid is not likely to enter raceways or enclosures to which the conduit is connected.

(2) In hoistways, other than as permitted in Section 620.21(A)(1)

(3) In storage-battery rooms

(4) In any hazardous (classified) location other than as permitted in Sections 501.4(B) and 504.20

(5) Where exposed to materials having a deteriorating effect on the installed conductors, such as oil or gasoline

(6) Underground or embedded in poured concrete or aggregate

(7) Where subject to physical damage

b. 358.10. Uses Permitted

(A) Exposed and Concealed. The use of EMT shall be permitted for both exposed and concealed work.

(B) Corrosion Protection. Ferrous or nonferrous electrical metallic tubing, elbows, couplings, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection and judged suitable for the condition.

(C) WET Locations. All supports, bolts, straps, screws, and so forth shall be of corrosion-resistant materials or protected against corrosion by corrosion-resistant materials.

358.12. Uses Not Permitted. Electrical metallic tubing shall not be used under the following conditions:

(1) Where, during installation or afterward, it will be subject to severe physical damage.

(2) Where protected from corrosion solely by enamel.

(3) In cinder concrete or cinder fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least 2 in. (50 mm) thick or unless the tubing is at least 18 in. (450 mm) under the fill.

(4) In any hazardous (classified) location except as permitted by Sections 502.4, 503.3, and 504.20.

(5) For the support of luminaires (fixtures) or other equipment except conduit bodies no larger than the largest trade size of the tubing.

(6) Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Exception: Aluminum fittings and enclosures shall be permitted to be used with steel electrical metallic tubing.

c. 344.10. Uses Permitted

(A) All Atmospheric Conditions and Occupancies. Use of rigid metal conduit shall be permitted under all atmospheric conditions and occupancies. Ferrous raceways and fittings protected from corrosion solely by enamel shall be permitted only indoors and in occupancies not subject to sever corrosive influences.

(B) Corrosion Environments. Rigid metal conduit, elbows, couplings, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection and judged suitable for the condition. FPN: See Section 300.6 for protection against corrosion.

(C) Cinder Fill. Rigid metal conduit shall be permitted to be installed in or under cinder fill where subject to permanent moisture where protected on all sides by a layer of noncinder concrete not less than 2 in. (50 mm) thick; where the conduit is not less than 18 in. (450 mm) under the fill; or where protected by corrosion protection and judged suitable for the condition.

(D) All supports, bolts, straps, screws, and so forth, shall be of corrosion-resistant materials or protected against corrosion by corrosion-resistant materials.

d. 350.10. Uses Permitted. Listed liquidtight flexible metal conduit shall be permitted to be used in exposed or concealed locations as follows:

   (1) Where conditions of installation, operation, or maintenance require flexibility or protection from liquids, vapors, or solids

   (2) As permitted by Sections 501.4(B), 502.4, 503.3, and 504.20 and in other hazardous (classified) locations where specifically approved, and by Section 553.7(B)

   (3) For direct burial where listed and marked for the purpose

   350.12 Uses Not Permitted. Liquidtight flexible metal conduit shall not be used as follows:

   (1) Where subject to physical damage

   (2) Where any combination of ambient and conductor temperature will produce an operating temperature in excess of that for which the material is approved

e. 334.10. Uses Permitted Type NM, Type NMC, and Type NMS cables shall be permitted to be used in the following:

   (1) One-and two-family dwellings

   (2) Multifamily dwellings permitted to be of types III, IV, and V construction except as prohibited in 334.12.

   (3) Other structures permitted to be of Types III, IV, and V construction except as prohibited in 334.12. Cables shall be concealed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

   (4) Cable trays, where the cables are identified for the use.

      (A) Type NM. Type NM cable shall be permitted as follows:

         (1) For both exposed and concealed work in normally dry locations except as prohibited in 334.10(3)

         (2) To be installed or finishe din air voids in masonry block or tile walls.

      (B) Type NMC. Type NMC cable shall be permitted as follows:

         (1) For both exposed and concealed work in dry, moist, damp, or corrosive locations, except as prohibited in 334.10(3)

         (2) In outside and inside walls of masonry block or tile

- (3) In a shallow chase in masonry, concrete, or adobe protected against nails or screws by a steel platae at least 1/16 in. (1.59 mm) thick and covered with plaster, adobe, or similar finish.

(C) Type NMS. Type NMS cable shall be permitted as follows:

- (1) For both exposed and concealed work in normally dry locations except as prohibited in 34.10(3)
- (2) To be installed or finshed in air voids in masonry block or tile walls.
- (3) To be used as permitted in Article 780.

334.12. Uses Not Permitted

(A) Types NM, NMC, and NMS. Types NM, NMC, and NMS cables shall not be used in the following:

- (1) As open runs in dropped or suspended ceilings in other than one and two family and multifamily dwellings
- (2) As service-entrance cable
- (3) In commercial garages having hazardous (classified) locations as provided in Section 511.3
- (4) In theaters and similar locations, except as provided in Article 518.4
- (5) In motion picture studios
- (6) In storage battery rooms
- (7) In hoistways or on elevators or escalators
- (8) Embedded in poured cement, concrete, or aggregate
- (9) In any hazardous (classified) locations, except as permitted by Sections 501.4(B), Exception, 502.4(B), Exception No. 1 and 504.20
- (10) Types NM and NMS. Types NM and NMS cable shall not be used as follows:
  - a. Where exposed to corrosive fumes or vapors
  - b. Where embedded in masonry, concrete, adobe, fill or plaster
  - c. In a shallow chase in masonry, concrete or adobe and covered with plaster, adobe or similar finish
  - d. Where exposed or subject to excessive moisture or dampness

f. 362.10 Uses Permitted. The use of electrical nonmetallic tubing and fittings shall be permitted in the following:

(1) In any building not exceeding three floors above grade

a. For exposed work, where not prohibited by 362.12

b. Concealed within walls, floors, and ceilings

(2) In any building exceeding three floors above grade, ENT shall be concealed within walls, floors, and ceilings where the walls, floors, and ceilings provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies. The 15-minute finish rated thermal barrier shall be permitted to be used for combustible walls, floors, and ceilings.

(3) In locations subject to severe corrosive influences as covered in section 300.6 and where subject to chemicals for which the materials are specifically approved

(4) In concealed, dry, and damp locations not prohibited by 362.12

(5) Above suspended ceilings where the suspended ceilings provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies, except as permitted in section 362.10(1)(a).

(6) Encased in poured concrete, or embedded in a concrete slab on grade where ENT is placed on sand or approved screenings, provided fittings identified for this purpose are used for connections

(7) For wet locations indoors as permitted in this section or in a concrete slab on or below grade, with fittings listed for the purpose

(8) Metric designatgor 16 through 27 (trade size 1/2 through 1) as listed manufactured prewired assembly

362.12. Uses Not Permitted. Electrical nonmetallic tubing shall not be used in the following:

(1) In hazardous (classified) locations, except as permitted by Section 504.20 and 505.15 (A)(1)

(2) For the support of luminaires (fixtures) and other equipment

(3) Where subject to ambient temperatures in excess of 50°C (122°F) unless listed otherwise

(4) For conductors whose insulation temperature limitations would exceed those for which the tubing is listed

(5) For direct earth burial

(6) Where the voltage is over 600 volts

(7) In exposed locations, except as permitted by 362.10(1), 362.10(5) and 362.10(7)

(8) In theaters and similar locations, except as provided in Articles 518 and 520

(9) Where exposed to the direct rays of the sun, unless identified as sunlight resistant

(10) Where subject to physical damage

g. 342.10. Uses Permitted

(A) All Atmospheric Conditions and Occupancies. Use of IMC shall be permitted under all atmospheric conditions and occupancies.

(B) Corrosion Environments. IMC, elbows, couplings, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection and judged suitable for the condition.

(C) Cinder Fill. IMC shall be permitted to be installed in or under cinder fill where subject to permanent moisture where protected on all sides by a layer of noncinder concrete not less than 2 in. (50 mm) thick; where the conduit is not less than 18 in. (450 mm) under the fill; or where protected by corrosion protection and judged suitable for the condition.

(D) Wet locations. All supports, bolts, straps, screws, and so forth, shall be of corrosion-resistant materials or protected against corrosion by corrosion-resistant materials.

h. 330.10. Uses Permitted. Where not subject to physical damage, Type MC cables shall be permitted as follows:

(1) For services, feeders, and branch circuits

(2) For power, lighting, control, and signal circuits

(3) Indoors or outdoors

(4) Where exposed or concealed

(5) Direct buried where identified for such use

(6) In cable tray

(7) In any raceway

(8) As open runs of cable

(9) As aerial cable on a messenger

(10) In hazardous (classified) locations as permitted in Articles 501, 502, 503, 504, and 505

(11) In dry locations and embedded in plaster finish on brick or other masonry except in damp or wet locations

(12) In wet locations where any of the following conditions are met:

  a. The metallic covering is impervious to moisture.

  b. A lead sheath or moisture-impervious jacket is provided under the metal covering.

  c. The insulated conductors under the metallic covering are listed for use in wet locations.

(13) Where single-conductor cables are used, all phase conductors and, where used, the neutral conductor shall be grouped together to minimmize induced voltage on the sheath.

330.12. Uses Not Permitted. Type MC cable shall not be used where exposed to the destructive corrosive conditions, unless the metallic sheath is suitable for the conditions or is protected by material suitable for the conditions:

(1) Direct burial in the earth

(2) In concrete

(3) Where exposed to cinder fills, strong chlorides, caustic alkalis or vapors of chlorine or of hydrochloric acids

i. 394.10. Uses Permitted. Concealed knob-and-tube wiring shall be permitted to be installed in the hollow spaces of walls and ceilings or in unfinished attics and roof spaces as provided in Section 394.23 only as follows:

(1) For extensions of existing installations

(2) Elsewhere by special permission.

394.12. Uses Not Permitted. Concealed knob-and-tube wiring shall not be used in the following:

(1) Commercial garages

(2) Theaters and similar locations

(3) Motion picture studios

(4) Hazardous (classified) locations

(5) Hollow spaces of walls, ceilings, and attics where such spaces are insulated by loose, rolled, or foamed-in-place insulating material that envelops the conductors

j. 386.10. Uses Permitted. The use of surface metal raceways shall be permitted in the following:

(1) In dry locations

(2) In Class I, Division 2 hazardous (classified) locations as permitted in Section 501.4(B)(3)

(3) Under raised floors, as permitted in Section 645.5(D)(2)

(4) Extension through walls and floors, surface metal raceway shall be permitted to pass transversely through dry walls, dry partitions, and dry floors if the lenght passing through is unbroken. Access to the conductors shall be maintained on both sides of the wall, partition, or floor.

b. 386.12. Uses Not Permitted. The use of surface metal raceways shall not be permitted in the following:

(1) Where subject to severe physical damage, unless otherwise approved

(2) Where the voltage is 300 volts or more between conductors, unless the metal has a thickness of not less than 0.040 in. (1.02 mm) nominal

(3) Where subject to corrosive vapors

(4) In hoistways

(5) Where concealed, except as permitted in Section 386.10(4)

Written Test

Name ______________________________

Date ______________________________ Score __________

Objective 1

Match the terms related to wiring methods with their definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Flexible Metal Conduit (Greenfield)
2. Cable Sheath
3. Exposed (as applied to wiring methods)
4. Premises Wiring (System)
5. Cable
6. Rigid Nonmetallic Conduit (PVC)
7. Rigid Metal Conduit
8. Raceway
9. Electrical Nonmetallic Tubing (ENT)
10. Type MC Cable
11. Concealed Knob-and-Tube Wiring
12. Electrical Metallic Tubing (EMT)
13. Nonmetallic-Sheathed Cable (Romex)
14. Liquidtight Flexible Metal Conduit (Sealtite)
15. Equipment
16. Fitting

_____ a. A factory assembly of two or more conductors having an overall covering.

_____ b. A covering over the conductor assembly that may include one or more metallic members, strength members, or jackets.

_____ c. On or attached to the surface or behind panels designed to allow access.

_____ d. That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of their associated hardware, fittings, and wiring devices, both permanently and temporarily installed, that extends form the service point of utility conductors or source of power such as a battery, a solar photovoltaic system, or a generator, transformer, or converter windings, to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

_____ e. An accessory, such as a locknut, bushing, or other part of a wiring system, that is intended primarily to perform a mechanical rather than an electrical function

_____ f. An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in the *NEC* . Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

_____ g. A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material.

_____ h. A wiring method using knobs, tubes, and flexible nonmetallic tubing for the protection and support of single insulated conductors.

_____ i. A listed metal raceway of circular cross section with integral or associated couplings, approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity.

_____ j. A listed metallic tubing of circular cross section approved for the installation of electrical conductors when joined together with listed fittings.

_____ k. A raceway of circular cross section made of helically wound, formed, interlocked metal strip.

_____ l. A listed raceway of circular cross section having an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core with associated couplings, connectors, and fittings and approved for the installation of electric conductors.

_____ m. A pliable corrugated raceway of circular cross section with integral or associated couplings, connectors, and fittings listed for the installation of electric conductors. It is composed of a material that is resistant to moisture and chemical atmospheres and is flame retardant, (A pliable raceway is a raceway that can be bent by hand with a reasonable force, but without other assistance).

_____ n. A factory assembly of one or more insulated circuit conductors with or without optical fiber members enclosed in an armor of interlocking metal tape, or a smooth or corrugated metallic sheath.

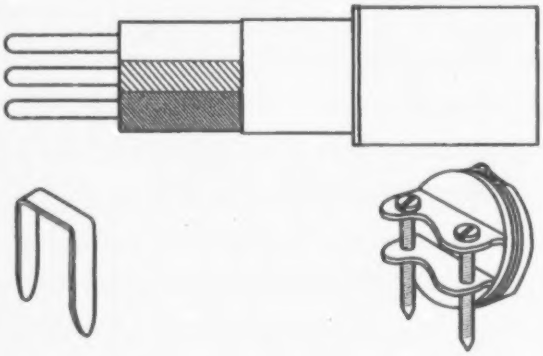
_____ o. A type of conduit and fittings of nonmetallic material that is resistant to moisture and chemical atmospheres and is suitable for underground use.

_____ p. A general term including material, fittings, devices, appliances, fixtures, and apparatus, used as part of, or in connection with, an electrical installation

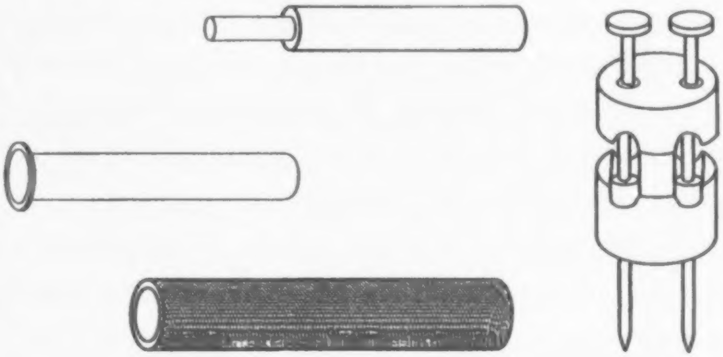
Written Test

Objective 2

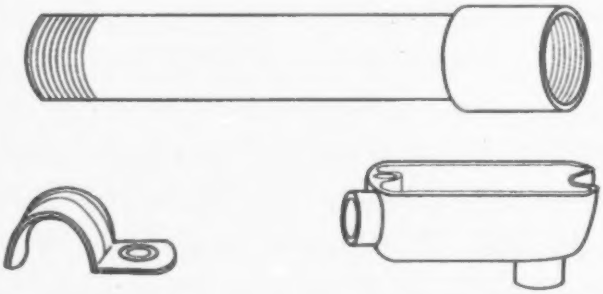
Identify the following wiring methods found in electrical trades. Write your answers in the blanks provided.



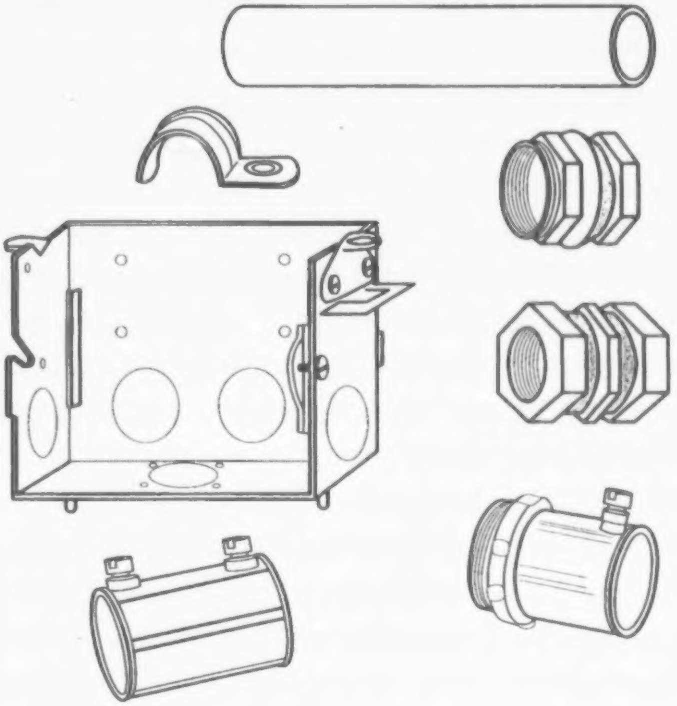
a. ____________________



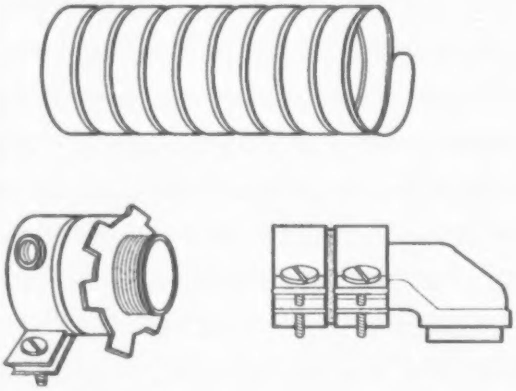
b. ____________________



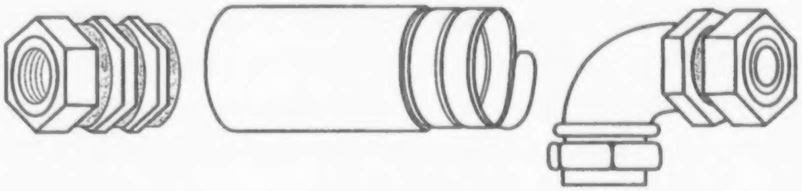
c. ____________________



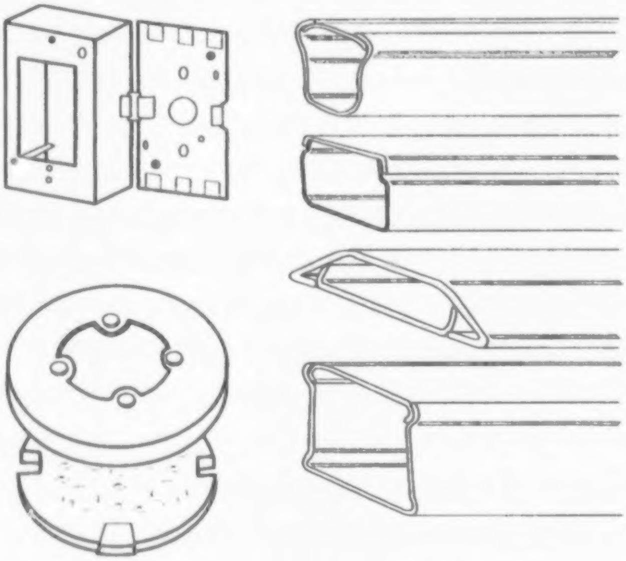
d. ______________________________



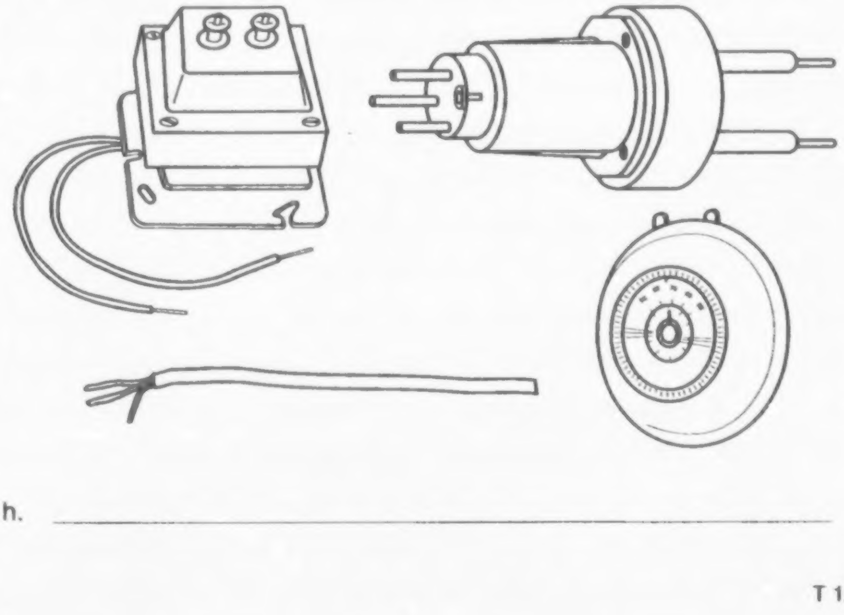
e. ______________________________



f. ______________________________

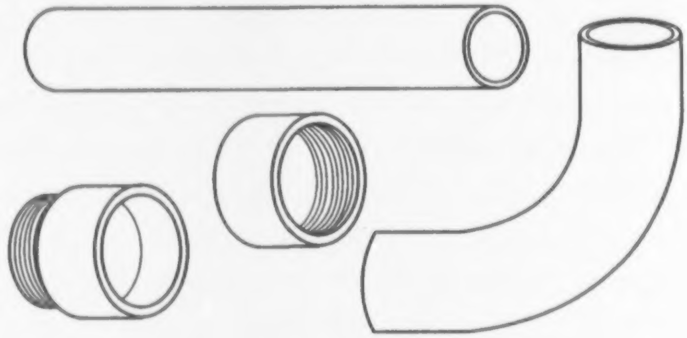


g. ______________________________

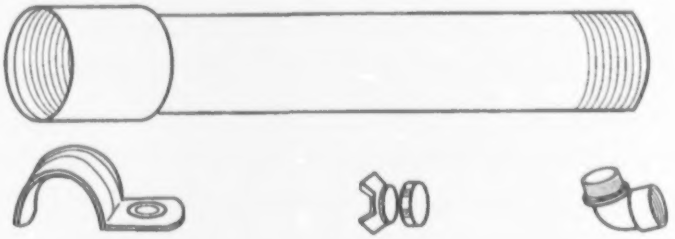


h. ______________________________

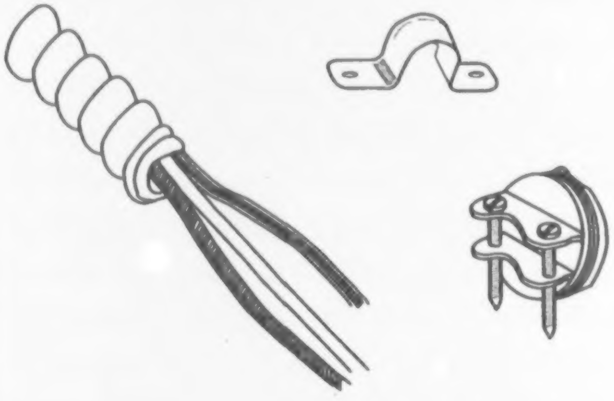
Written Test



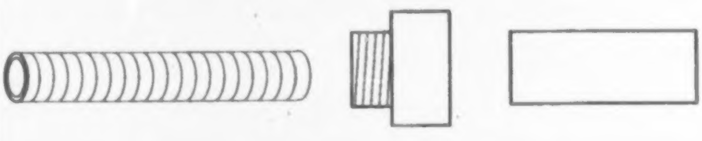
i. ____________________



j. ____________________



k. ____________________



l. ____________________

Written Test

Objective 3

Match wiring methods with their common applications. Write the correct numbers in the blanks.

1. Liquidtight flexible metal conduit
2. Electrical metallic tubing
3. Cable
4. Low voltage
5. Concealed knob-and-tube wiring
6. Rigid metal conduit
7. Surface raceways
8. Flexible metal conduit
9. Electrical nonmetallic tubing
10. Rigid nonmetallic conduit (PVC)
11. Intermediate metal conduit
12. Metal-clad cable

_____ a. Nonmetallic sheathed cable: general residential rough-in and circuit extensions in existing dwellings; underground feeder and branch circuit cable (UF): direct burial for yard lights or extensions

_____ b. Extensions of existing installations, elsewhere by special permission

_____ c. Through-eave service masts; underground circuit extension; in concrete walls, floors, or ceilings; underground service riser; commercial and industrial locations; hazardous locations

_____ d. Service raceway, protecting grounding electrode conductor, commercial and industrial locations

_____ e. Connecting recessed lighting fixtures, enclosing motor leads

_____ f. Connecting air conditioning condensers to disconnects, enclosing motor leads needing protection from liquids and vapors

_____ g. Interior circuit extensions where concealed work is not necessary or not possible, on interior concrete surfaces

_____ h. Chime circuits, intercom wiring, thermostat circuits, lighting control

_____ i. Locations subject to severe corrosive influences; suspended ceilings; concealed within walls, floors, and ceilings

_____ j. Services; feeders; branch circuits; power, lighting, and signal circuits

_____ k. Lighter weight and thinner wall than rigid, all atmospheric conditions, hazardous locations, underground circuits

_____ l. Underground circuits, wet locations, where subject to corrosion or chemicals. Schedule 80 where exposed to physical damage.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 5
b. 2
c. 3
d. 4
e. 16
f. 8
g. 13
h. 11
i. 7
j. 12
k. 1
l. 14
m. 9
n. 10
o. 6
p. 15

Objective 2

a. Nonmetallic-sheathed cable (Romex)
b. Concealed knob-and-tube wiring
c. Rigid metal conduit
d. Electrical metallic tubing (EMT)
e. Flexible metal conduit
f. Liquidtight flexible metal conduit
g. Surface raceways
h. Low voltage
i. Rigid nonmetallic conduit (PVC) fittings and connections
j. Intermediate metal conduit
k. Metal clad cable
l. Electrical nonmetallic tubing

Objective 3

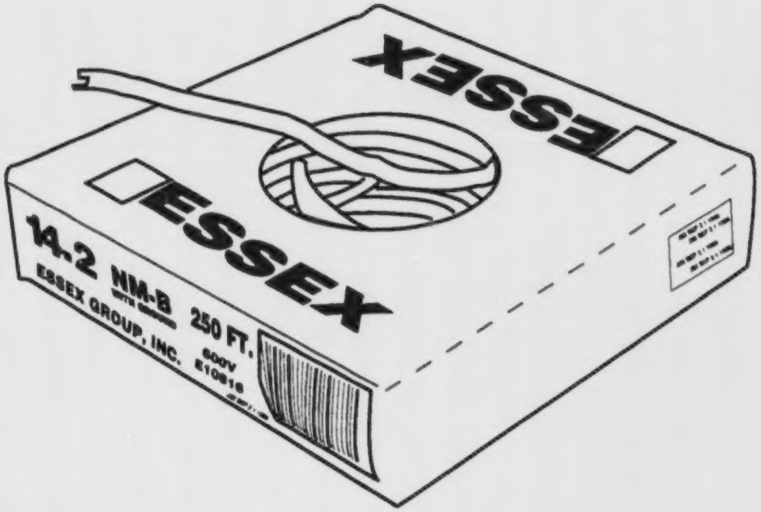
a. 3
b. 5
c. 6
d. 2
e. 8
f. 1
g. 7
h. 4
i. 9
j. 12
k. 11
l. 10

Teacher Supplement 1—Various Environments and Structures Requiring Electrical Wiring Installations

This supplement is intended to be used in conjunction with the Focus Assignment.

- Commercial Buildings such as banks, clothing stores, grocery stores, etc.
- Underground or buried installations
- Auto repair garages
- Places of assembly such as churches, auditoriums, etc.
- Aircraft hangers
- Corrosive atmospheres such as chemical treatment plants
- Agricultural buildings
- Health care facilities
- Industrial factories
- Hazardous locations such as gas stations and paint booths
- Marinas and boat docks
- Schools

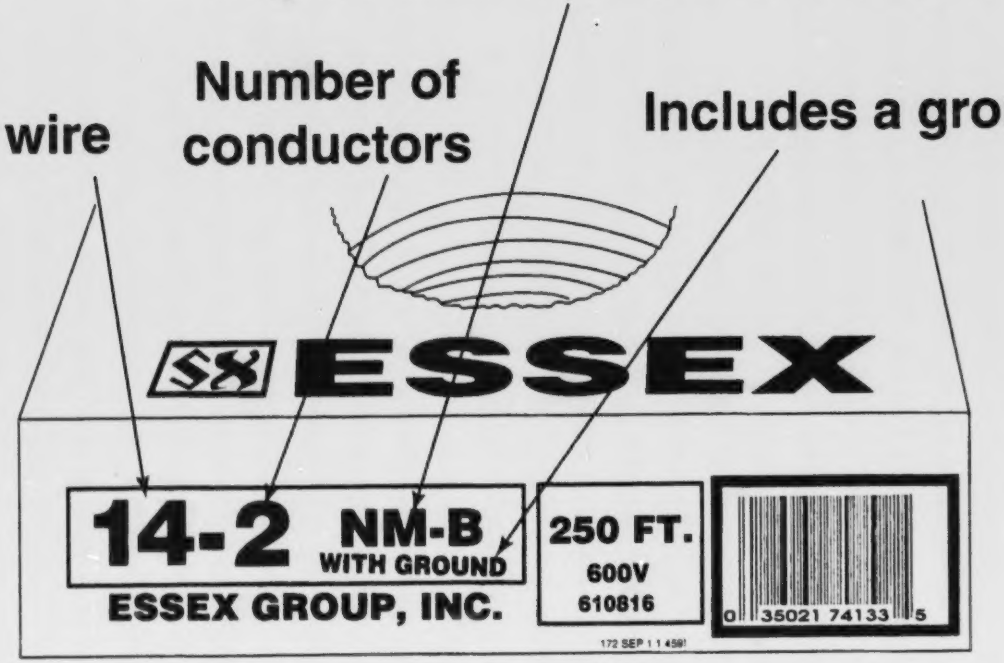
Nonmetallic Sheathed Cable


ESSEX
ESSEX
14-2 NM-B
250 FT.
ESSEX GROUP, INC.
600V

- **Romex is a brand name for Nonmetallic Sheathed Cable (NM).**
- **The main type of wiring in a residence.**
- **Found in NEC Article 334.**

TM 1

Nonmetallic Sheathed Cable (continued)



NM=Nonmetallic,
B=*NEC* designation for 90 degree celsius rated insulation

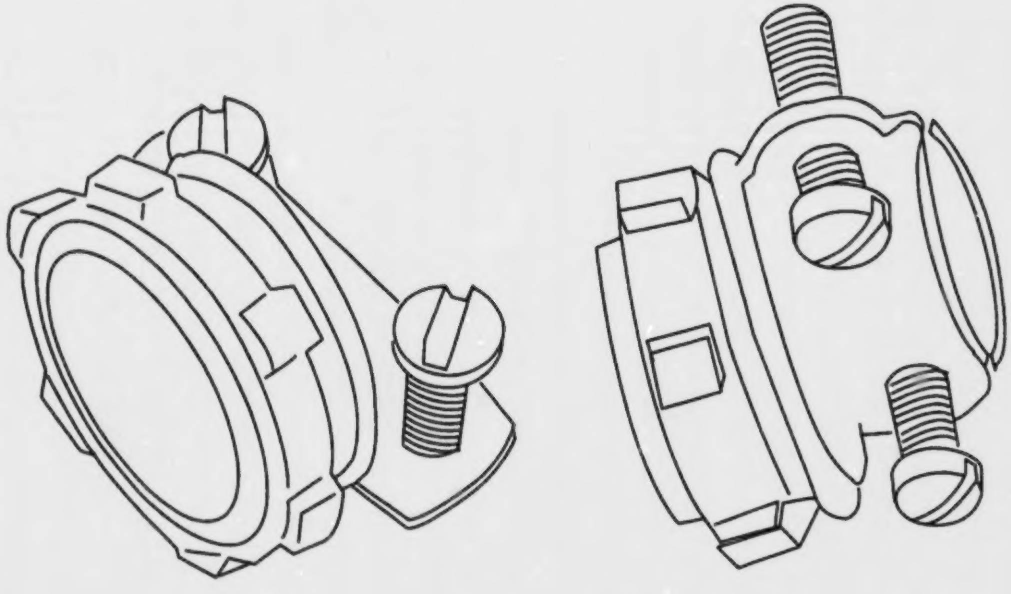
Size of wire

Number of conductors

Includes a ground

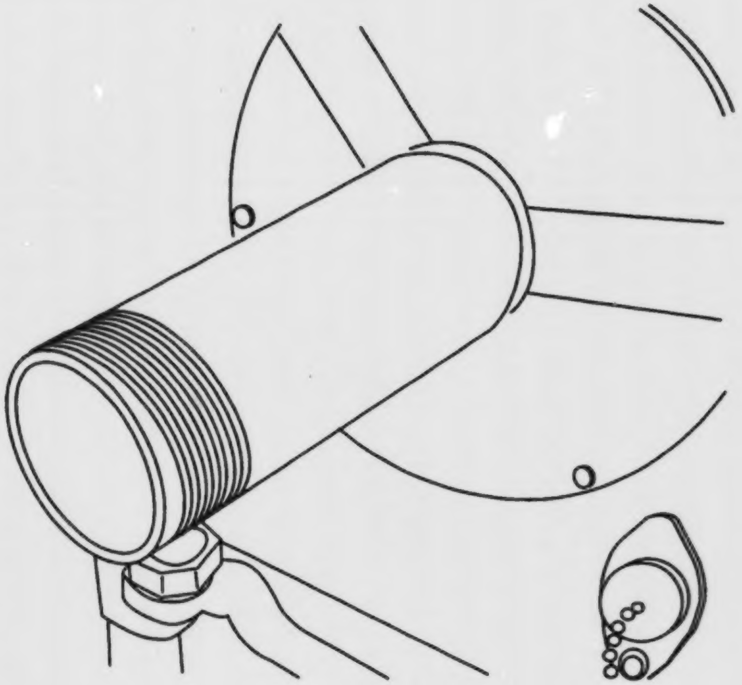
ESSEX
14-2
NM-B
WITH GROUND
ESSEX GROUP, INC.
250 FT.
600V
610816
172 SEP 1 1 4591

Romex Connectors



Connection to a box is done with romex connectors

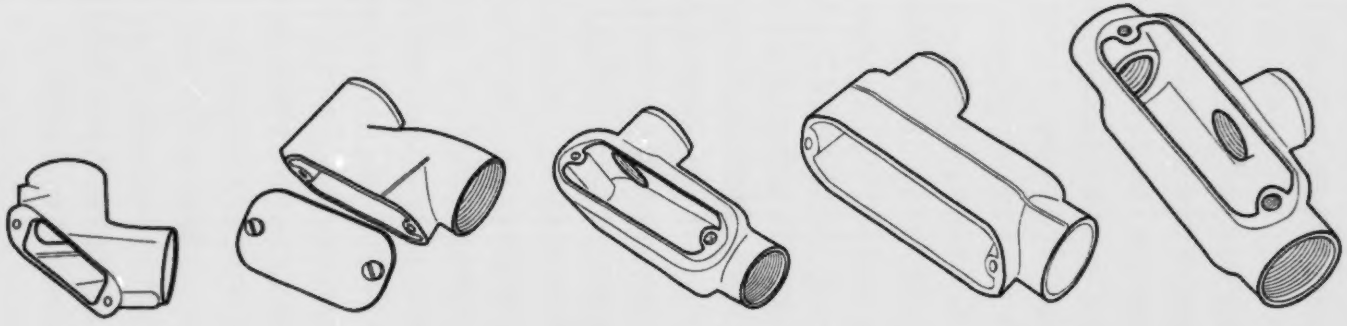
Rigid Metal Conduit



- **Available in diameters of 1/2″ (16) to 6″ (155).**
- **Found in *NEC* Article 344.**

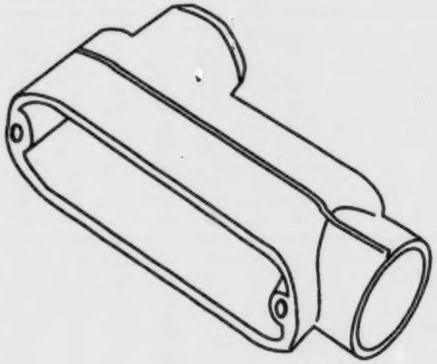
TM 4

Rigid Metal Conduit Bodies

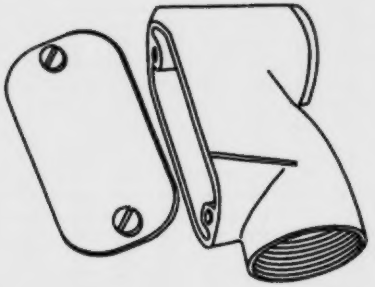


- Used to aid in running and pulling wire through conduit.
- *NEC* Article 100 - Conduit Body: Conduit bodies are a portion of a raceway system with removable covers to allow access to the interior of the system. They include the "short radius" type as well as capped elbows and service entrance elbows.
- Available for any size of conduit.
- Nonmetallic conduit bodies are also available.

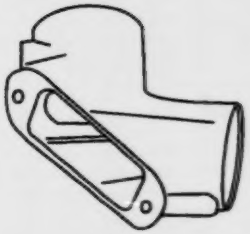
Rigid Metal Conduit Bodies (continued)



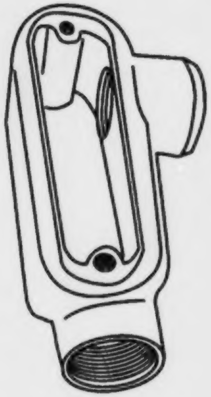
LB



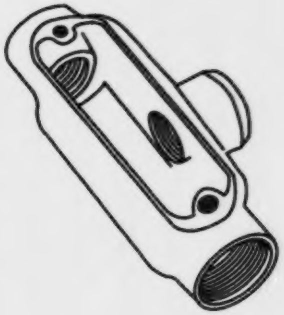
Short LB



Jake L



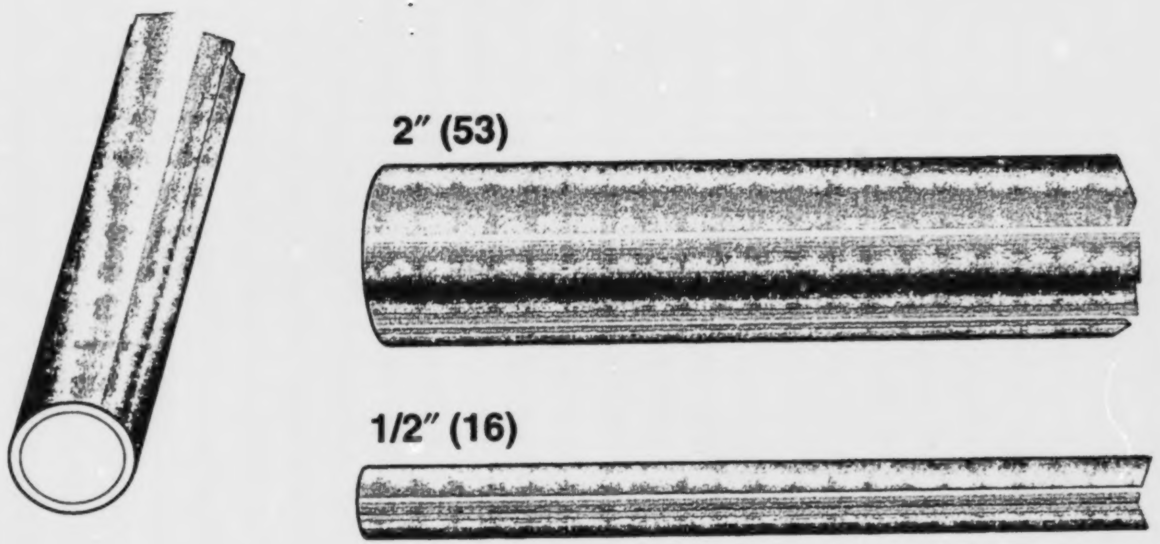
LL



T

(LR is also available)

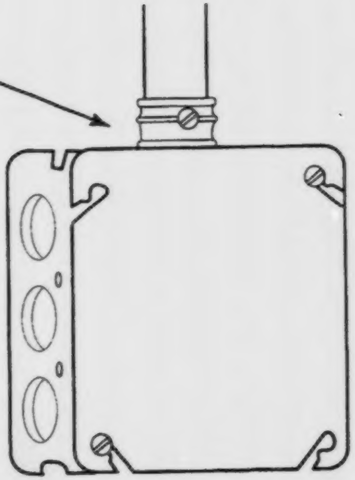
Electrical Metallic Tubing (EMT)



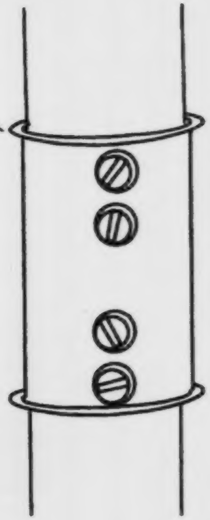
- Available in diameters from 1/2″ (16) to 4″ (103) .
- Found in *NEC* Article 358.

Conduit Fittings

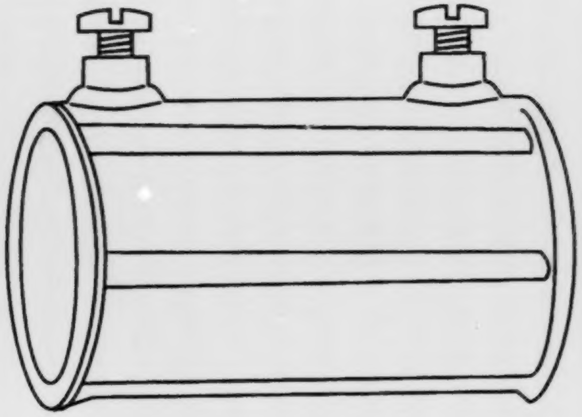
- *Connectors* connect to the box.



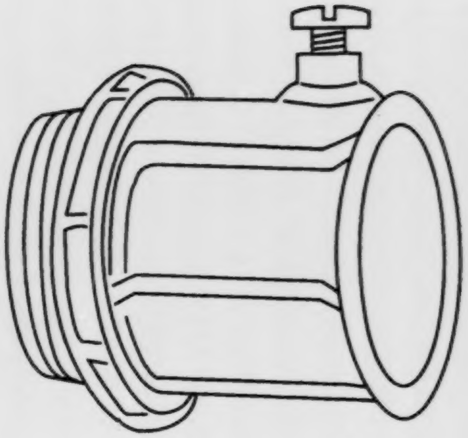
- *Couplings* couple two pieces of pipe together.



Set Screw Fittings

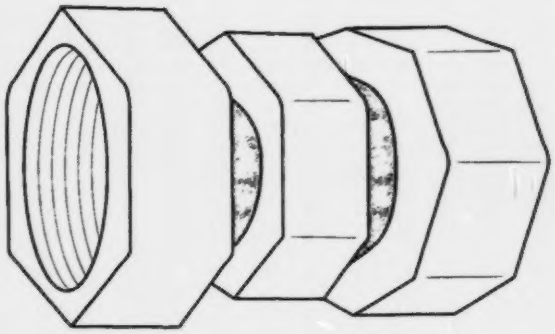


Setscrew EMT Coupling

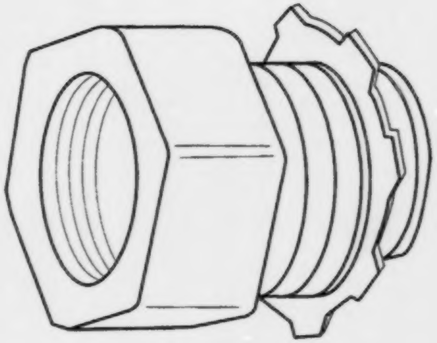


Setscrew EMT Connector

Compression or Raintight Fittings



Raintight EMT Coupling

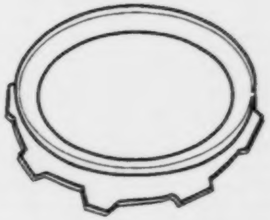


Raintight EMT Connector

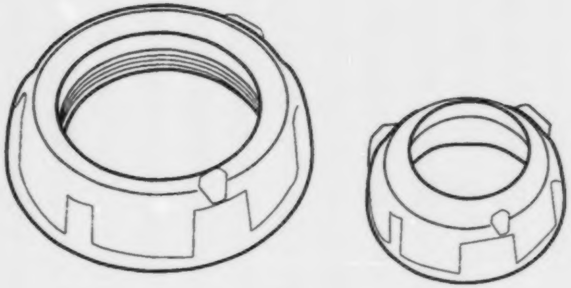
Used outdoors, the compression ring does not allow water inside the raceway.

Locknuts and Bushings

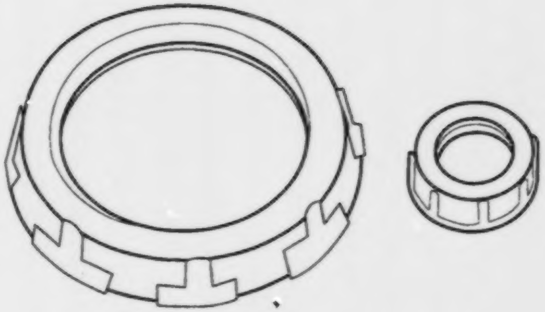
- The locknut holds the connector to the box.



Locknut



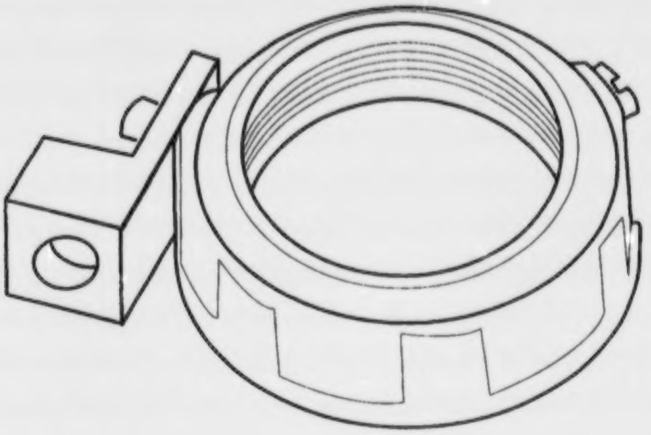
Plastic Bushing

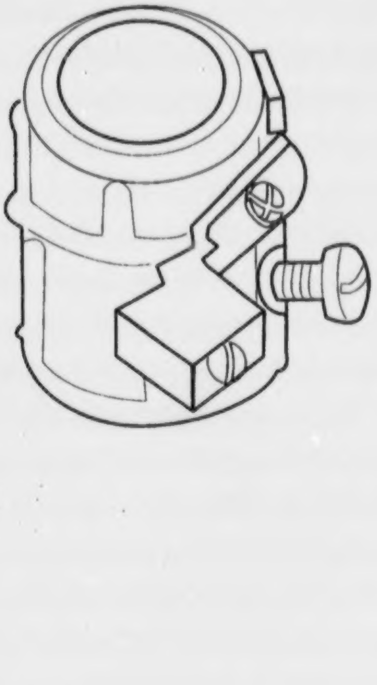


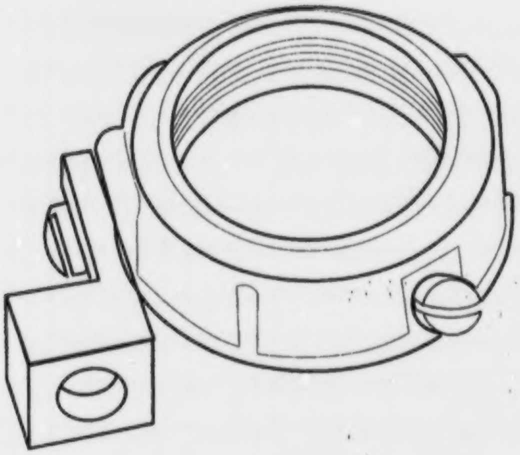
Metal Bushing

- The bushing protects the wires from the sharp conduit edges.

Grounding Bushing

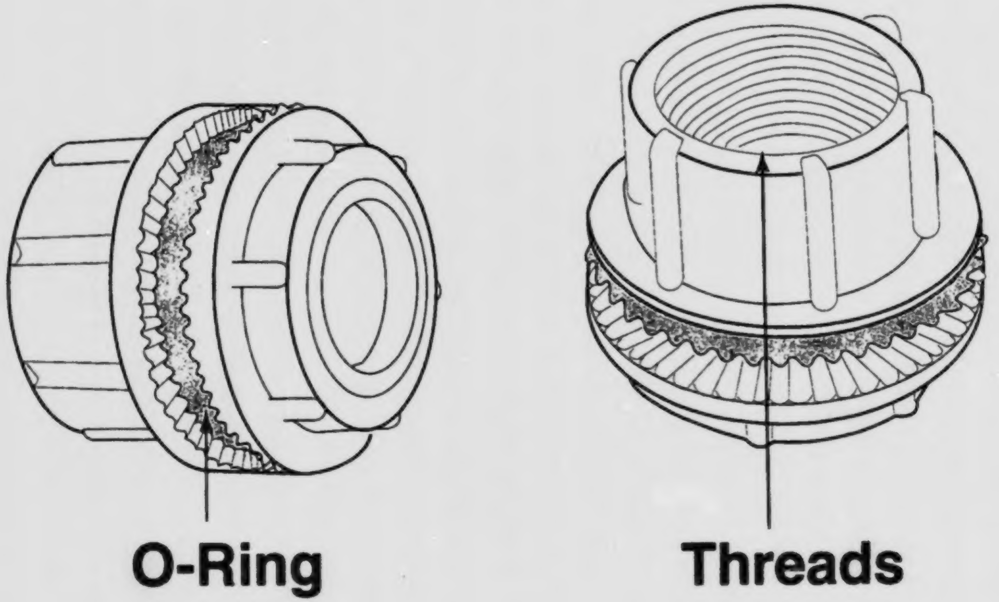






Used when extra grounding or bonding is needed for conduit.

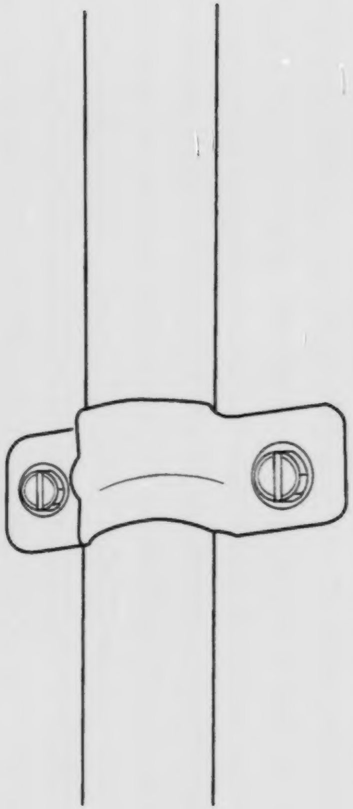
Meyers Hub



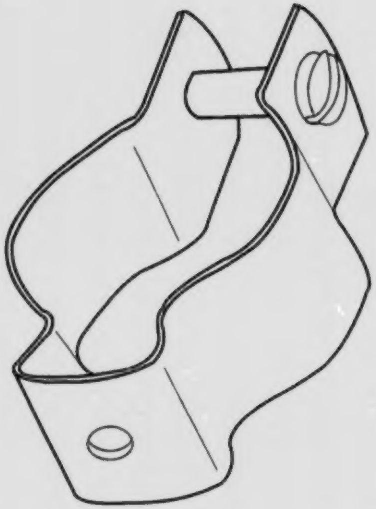
- Used outdoors in the top of enclosurers.
- Has an o-ring and threads to keep water from running down into the box.

Supports

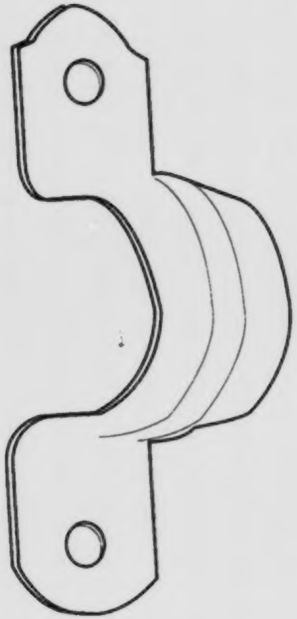
- Supports are various straps and supporting materials for conduit.



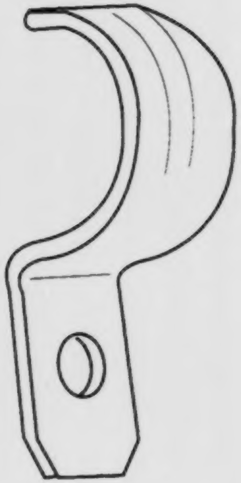
Three Common Types of Straps



Mineralac or
Stand off strap

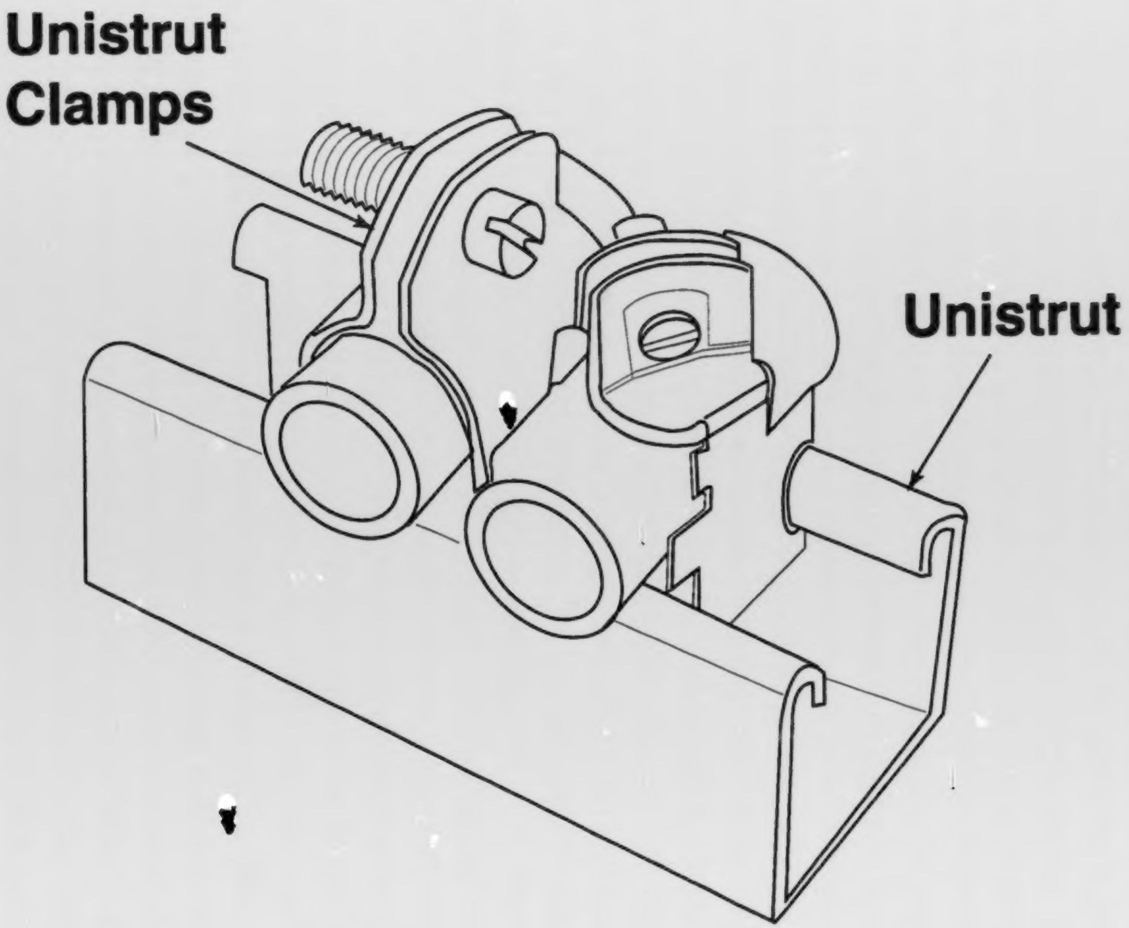


Two hole strap

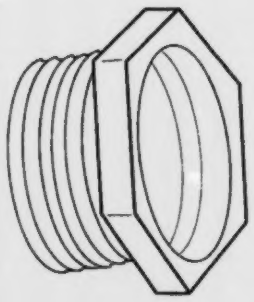


One hole strap

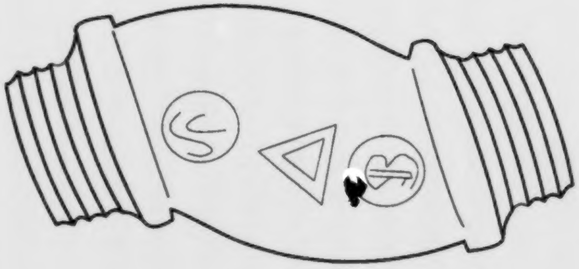
Unistrut and Unistrut Clamps (Sometimes called Kendorf)


Unistrut Clamps
Unistrut

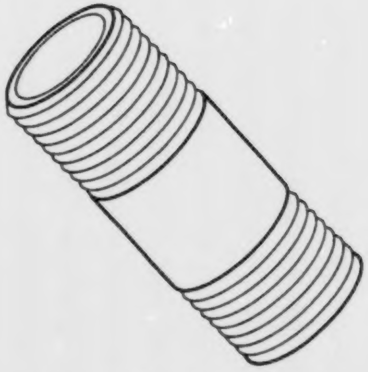
Nipples
(Any piece of conduit less than 24")



Chase Nipple



Offset Nipple

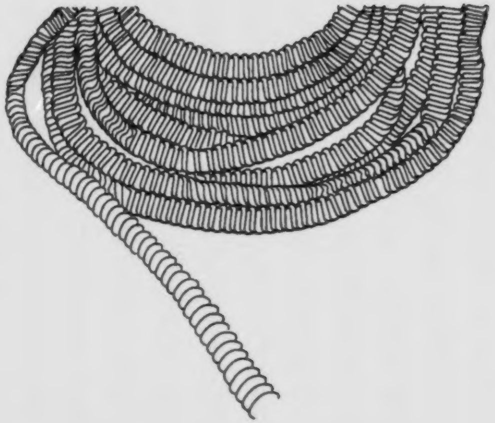


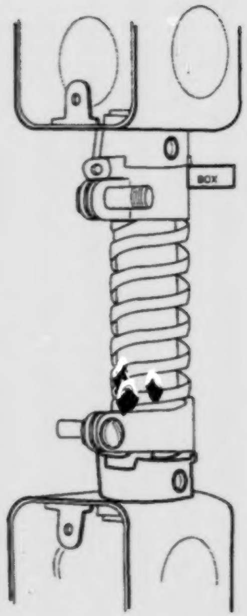
1/2" (16) x 2" (53) nipple

size of conduit
length of nipple

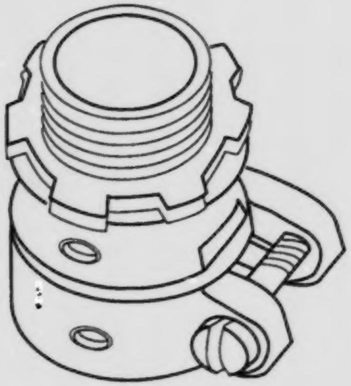
Flexible Metal Conduit

- Also called Greenfield.
- Used for flexible dry installations.
- Found in *NEC* Article 348.
- Greenfield is a brand name.

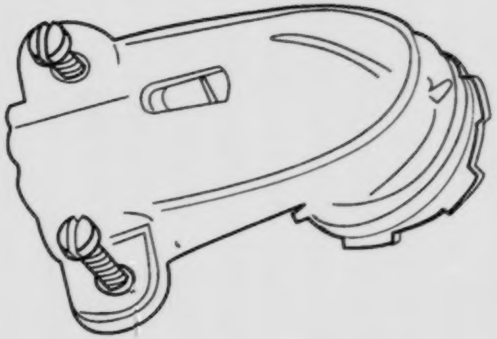




Flexible Metal Conduit Connectors

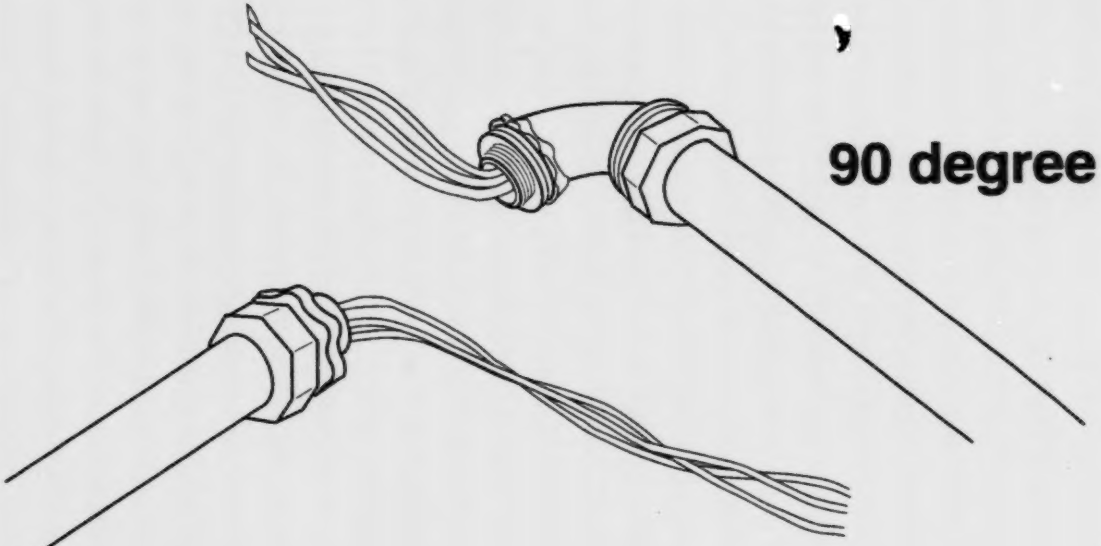


Straight connector



90° connector

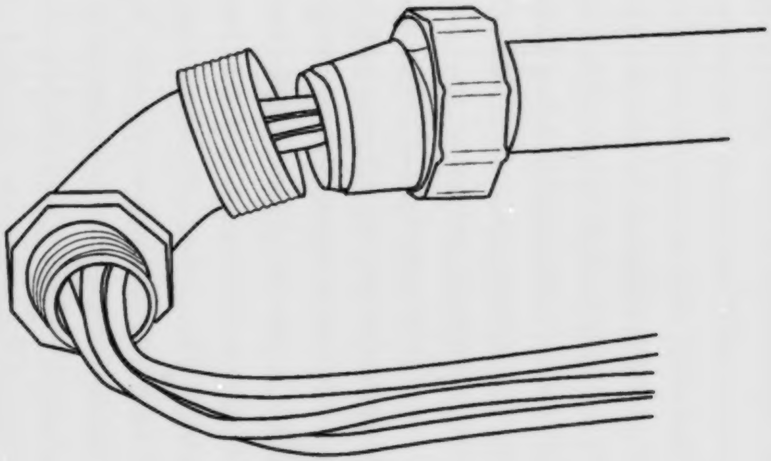
Liquidtight Flexible Metal Conduit Connectors



90 degree connector

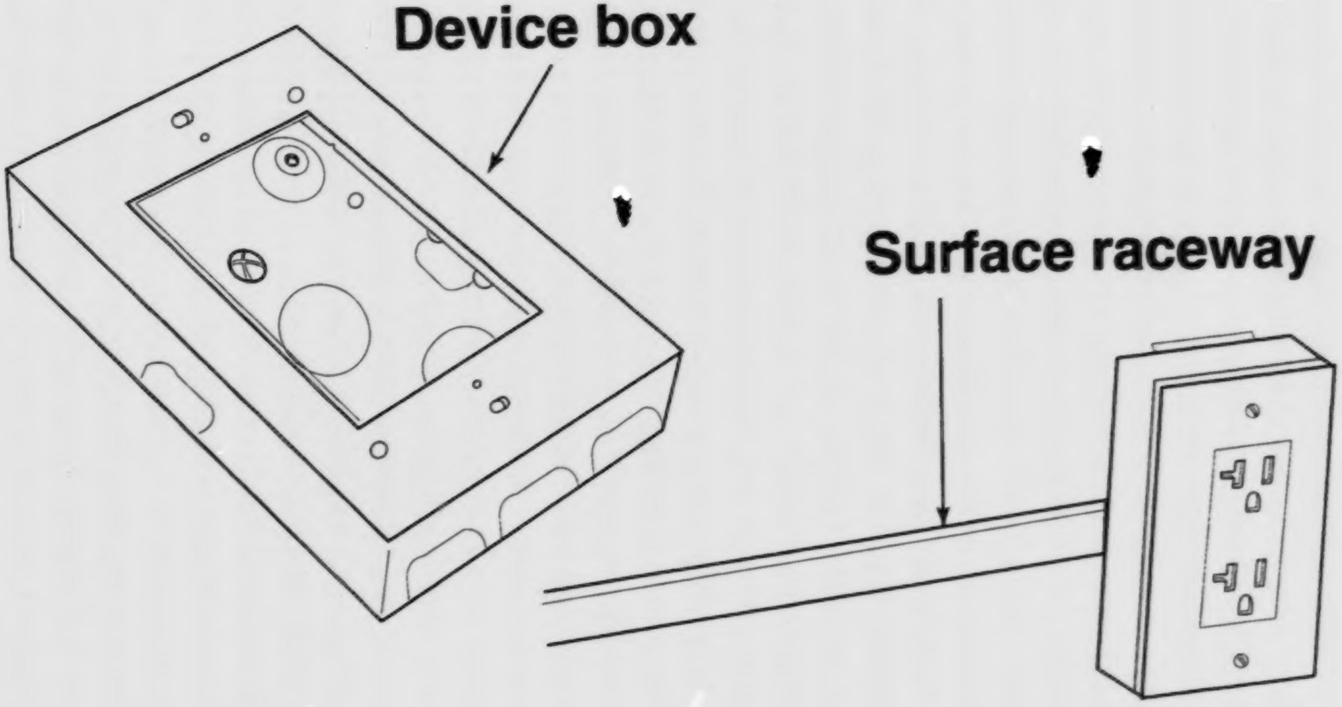
Straight connector

Liquidtight Flexible Metal Conduit Connectors (continued)

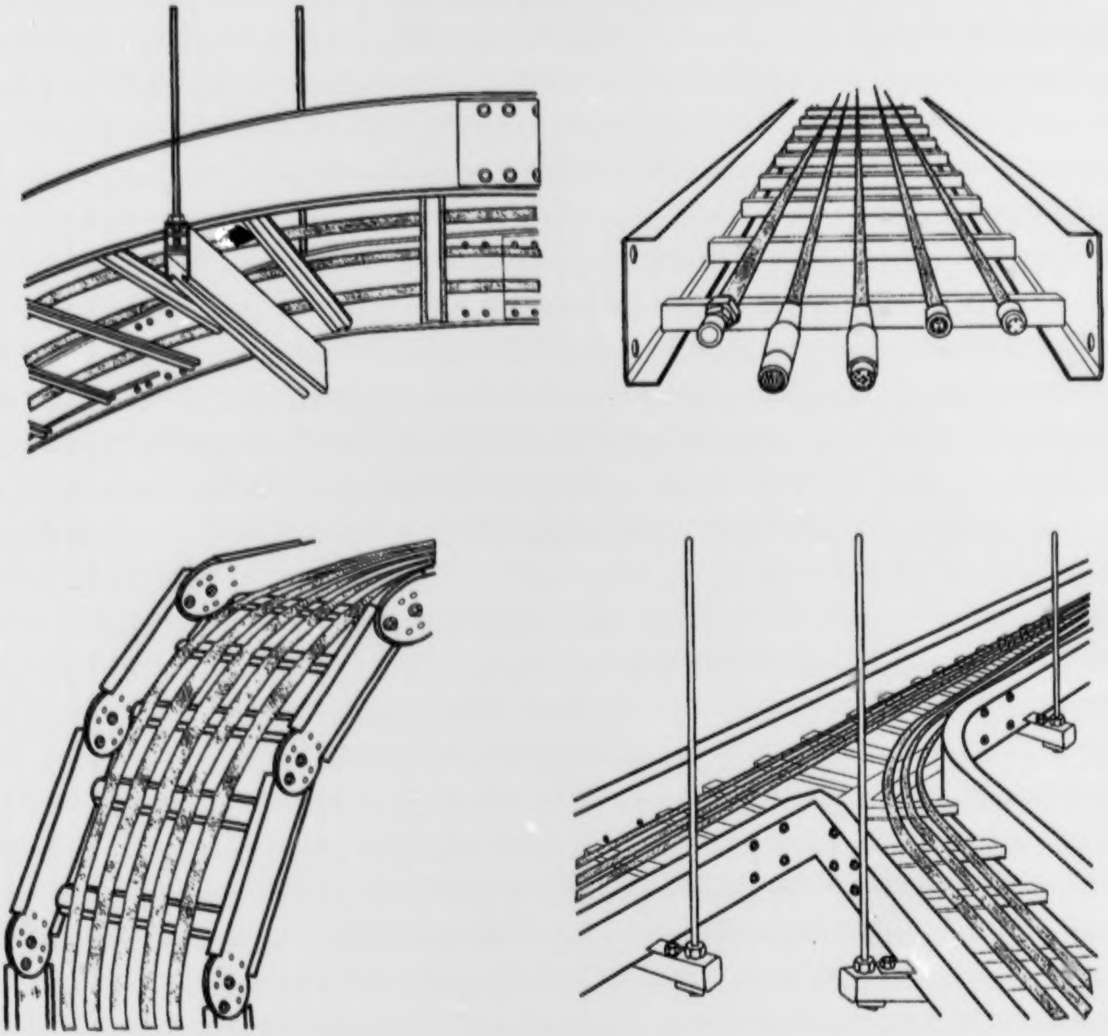


- **The liquid tight connector assembly prevents moisture from entering the conduit.**

Device Box and Surface Raceway

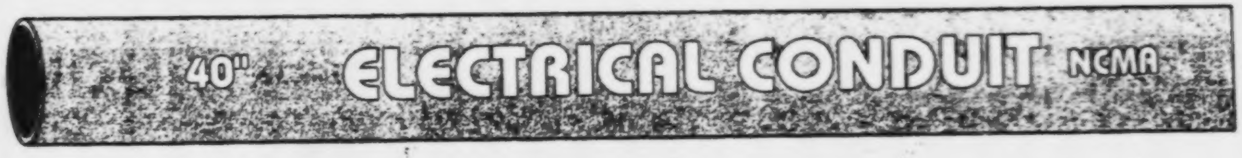

Device box
Surface raceway

Cable Trays



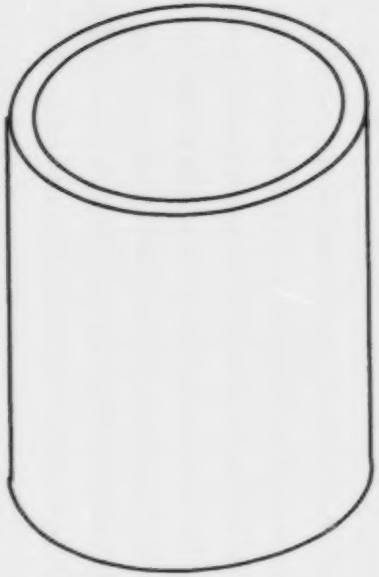
- **Used to support wires and cable.**
- **Allows easy access.**

Rigid Nonmetallic Conduit (PVC)

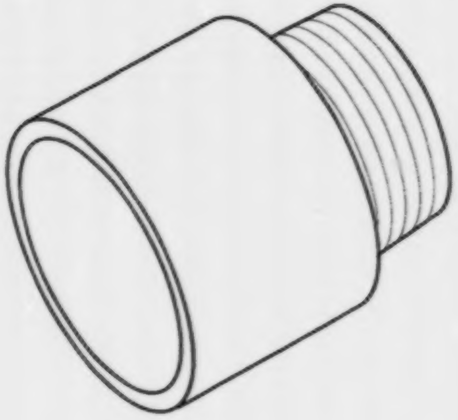

40"
ELECTRICAL CONDUIT
NCMA

- Available in diameters from 1/2" (16) to 6" (155).
- Found in *NEC* Article 352.

PVC Fittings



PVC coupling

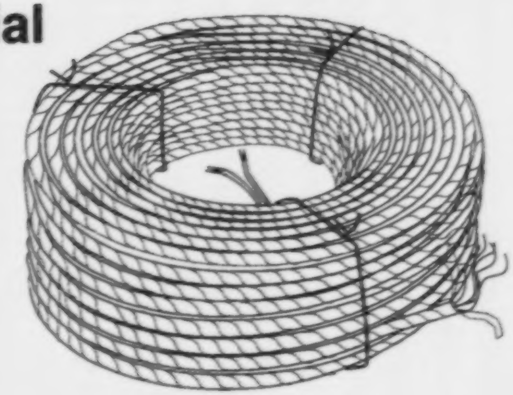


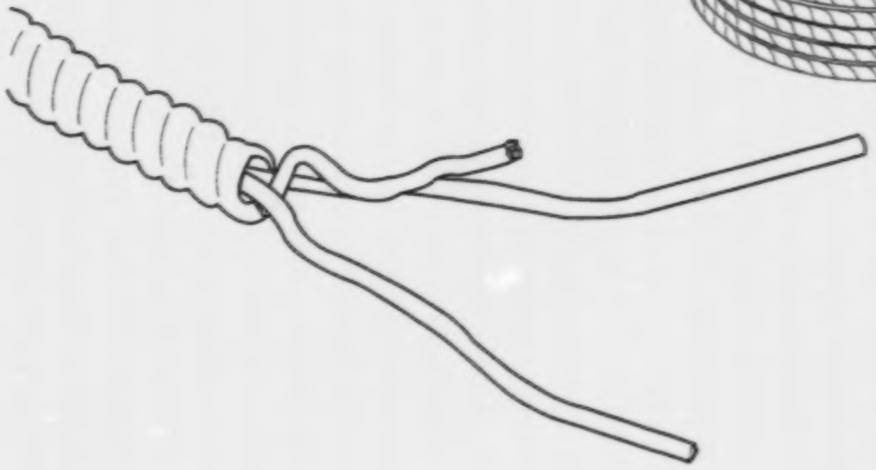
PVC connector

- Glue into place.

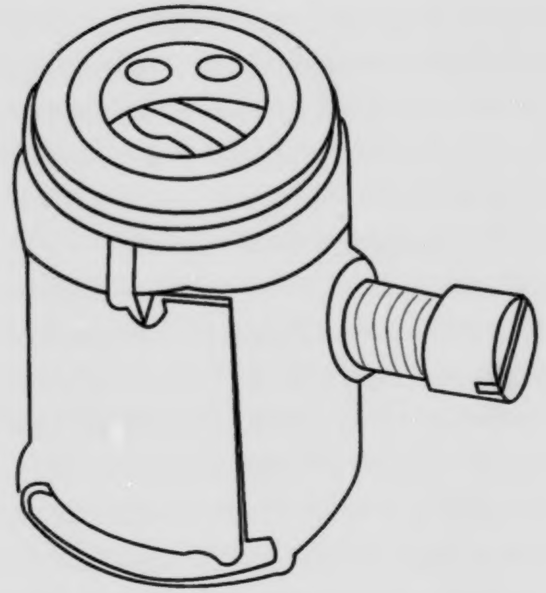
Metal Clad (MC) Cable

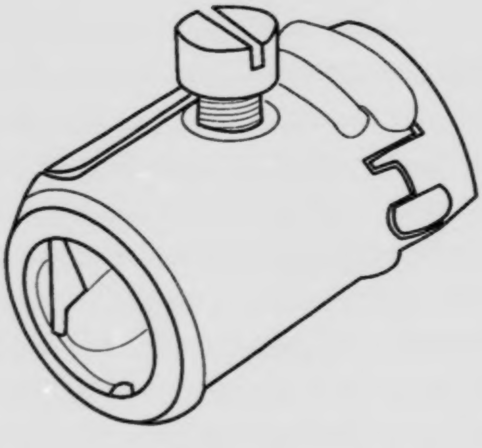
- Available for light commercial and residential wiring.
- Found in *NEC* Article 330
- Wires are factory installed





Metal Clad Cable Connectors





TM 27

Unit 13 Conductors

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 13–3

Answers to Assignment Sheets 13–9

Written Test 13–13

Answers to Written Test 13–21

Transparency Masters

- 1—AWG Conductor Sizes 13–23
- 2—Ambient Temperature 13–25
- 3—Overcurrent Protection 13–27

Student Components

Student Page

Learning Activities Sheet 13–3

Objective Sheet 13–7

Information Sheet 13–9

* Focus Assignment

- Report on a Fire 107

* Assignment Sheets

- 1—List Conductors in Order, By Size 109
- 2—Calculate Ampacity of Conductors, Given Insulation and Conductor Type 111
- 3—Calculate Corrected Ampacity of Conductors 113
- 4—Select Conductors for Various Ampacities and Temperatures . . 115
- 5—Calculate Ampacity of Conductors, Given Number of Conductors in Raceway 117
- 6—Calculate Ampacity and Conductor Sizes for Specific Types of Loads. 119
- 7—Select Cords for Various Applications 121
- 8—Select Proper Types of Insulation 123

* Job Sheets

- 1—Install Cord on Utilization Equipment 125
- 2—Use a Fish Tape to Install Wire in Conduit 127
- 3—Prepare an Aluminum Conductor for Termination 129
- 4—Splice Solid Conductors Using a Wire Nut 131

* Focus Assignment, Assignment Sheets and Job Sheets are located in Student Workbook 2.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM 1—AWG Conductor Sizes
TM 2—Ambient Temperature
TM 3—Overcurrent Protection

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Construct a display of conductors, showing types and sizes.
- Construct a display of cords and cables, showing types and sizes.
- Invite a local supplier to demonstrate termination methods.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Clidera, Robert and Kenneth Sharpe. *Construction Wiring.* Albany, NY: Delmar Publishers.
- Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993.* Quincy, MA: National Fire Protection Association, 1992.
- *National Electrical Code, 2002.* Quincy, MA: National Fire Protection Association, 2001.
- Taylor, Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution.* Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.
- *National Electrical Code,* 1999. Quincy MA: National Fire Protection Association, 1998.

Suggested Activities

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes.* Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC

- *NEC 2002 Handbook.* Quincy, MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics

  The publication(s) listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org

- Early, Mark W., et al. *Illustrated Changes in the National Electrical Code.* Delmar Publishers, Inc. 2002.

  Provides a detailed view fo the most important changes in the 2002 NEC

- Herman, Stephen L. *Electrician's Technical Reference: Electrical Theory and Calculations.* Delmar Publishers, Inc. 2002.

  Provides detailed examples of problem-solving for different kinds of DC and AC circuits

- Loyd, Richard. *Electrician's Technical Reference: Wiring Methods.* Delmar Publishers, Inc. 1999.

- Miller, Chris. *Illustrated Guide to the National Electrical Code,* 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type or occupancy, and contains 600 illustrations

- O'Riley, Ronald. *Electrical Grounding,* 6th ed. Delmar Publishers, Inc. 2002.

- Simpson, James G. *Common Sense Conduit Bending and Cable Tray Techniques.* Delmar Publishers, Inc. 1996.

  Geared especially for students

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code,* 6th ed. Delmar Publishers, Inc. 2002.

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied

- Wetherell, Austin. *Wire and Cable Marking Guide*, 4th ed. Underwriters Laboratory, Inc. 1997.

Electronic Media

- 3M Company manufacturer of conductor splicing kits: http://www.mmm.com/
- Underwriters Laboratories Inc.: http://www.ul.com/index.html
- Ideal Home Page–manufacturers of splice and tools for wires: http://www.idealindustries.com

Answers to Assignment Sheets

Assignment Sheet 1

List conductors in order, by size

a. #18 AWG
b. #16 AWG
c. #14 AWG
d. #12 AWG
e. #10 AWG
f. #8 AWG
g. #6 AWG
h. #4 AWG
i. #3 AWG
j. #2 AWG
k. #1 AWG
l. #1/0 AWG
m. #2/0 AWG
n. #3/0 AWG
o. #4/0 AWG
p. 250 KCMIL
q. 300 KCMIL
r. 350 KCMIL
s. 400 KCMIL
t. 500 KCMIL
u. 600 KCMIL
v. 700 KCMIL
w. 800 KCMIL
x. 900 KCMIL
y. 1000 KCMIL
z. 1250 KCMIL
aa. 1500 KCMIL
bb. 1750 KCMIL
cc. 2000 KCMIL

Assignment Sheet 2

Title of Assignment Sheet

a. 75
b. 95
c. 205
d. 475
e. 25
f. 40
g. 18
h. 350
i. 665
j. 150

Answers to Assignment Sheets

Assignment Sheet 3

Calculate corrected ampacity of conductors

a. 75, .71, 53.25
b. 30, 1.00, 30
c. 495, .58, 287.1
d. 385, 1.05, 404.25
e. 195, .82, 159.9

Assignment Sheet 4

Select conductors for various ampacities and temperatures

a. #12 AWG
b. #8 AWG
c. #10 AWG
d. #3 AWG
e. #2 AWG
f. #250 MCM
g. #500 MCM
h. #1750 MCM
i. #4 AWG
j. #4 AWG
k. #000 AWG

Assignment Sheet 5

Calculate ampacitiy of conductors, given number of conductors in raceway

a. 50 amperes
b. 35 amperes
c. 85 amperes
d. 175 amperes
e. 255 amperes
f. 100 amperes
g. 40 amperes
h. 15.75 amperes
i. 59.5 amperes
j. 122.5 amperes
k. 178.5 amperes
l. 50 amperes

Assignment Sheet 6

Calculate ampacitly and conductor sizes for specific types of loads

Part 1
a. 125%, 33.75, #8 AWG
b. 125%, 81.25, #4 AWG
c. 125%, 96.25, #3 AWG

Part 2
a. 140%, 60.2, #6 AWG
b. 150%, 135, #1 AWG
c. 85%, 93.5, #4 AWG
d. 120%, 103.2, #3 AWG
e. 150%, 40.5, #8 AWG

Assignment Sheet 7

Select cords for various applications

	Type	Size
a.	C	#10 AWG
b.	SVTOO	#17 AWG
c.	SRD, SRDE, SRDT	#10 AWG
d.	HPD	#14 AWG

Assignment Sheet 8

Select proper types of insulation

Part 1

a. MTW, THW, THWN
b. MTW
c. T, TW, THHN, THW, THWN
d. TW, MTW, THW, THWN
e. THHN, MTW, THW, THWN

Part 2

a. 250°C, 482°F
b. 60°C, 140°F
c. 75°C, 167°F
d. 90°C, 194°F
e. 60°C, 140°F
f. 90°C, 194°F
g. 75°C, 167°F
h. 90°C, 194°F
i. 150°C, 302°F
j. 75°C, 167°F
k. 200°C, 392°F
l. 90°C, 194°F
m. 75°C, 167°F
n. 90°C, 194°F
o. 75°C, 167°F

Written Test

Name ____

Date ________________________________ Score____________

Objective 1

Match the terms related to conductors with their correct definitions. Definitions continue on the next page. Write the correct numbers in the blanks.

1. Aluminum wire
2. Ampacity
3. American wire gauge (AWG)
4. Bare conductor
5. Cable
6. Circular mils
7. Color coding
8. Copper-clad aluminum
9. Copper wire
10. Cord
11. Covered
12. Fish tape
13. Grounded conductor
14. Insulated
15. KCMil
16. Type letter
17. Grounding conductor

_____ a. Conductor made of aluminum

_____ b. The diameter of a conductor in thousandths of inches multiplied times itself

_____ c. Assigning colors to conductors based on their uses

_____ d. A conductor having no covering or electrical insulation

_____ e. A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant nonmetallic material

_____ f. Two-(or more) stranded conductors grouped together in a flexible covering

_____ g. Conductor made of copper

_____ h. The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

_____ i. A series of specified diameters and thicknesses established as a standard in the United States; also known as Brown and Sharp gauge (B and S gauge)

_____ j. Aluminum conductor with an outer coating of copper metallurgically bonded to the aluminum core

_____ k. Conductor encased within material of composition or thickness not recognized by the *NEC* as electrical insulation

_____ l. Identification accepted by the trade in referring to the particular types of insulation

_____ m. One thousand circular mils

_____ n. Conductor encased within material of composition and thickness recognized by the *NEC* as electrical insulation

_____ o. Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

_____ p. Conductors used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

_____ q. A system or circuit conductor that is intentionally grounded (connected to the earth or some conductor that serves in place of the earth)

Objective 2

List six factors that determine type and size of conductors.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Objective 3

Select from the following list, characteristics of good connections. Write an "X" in the blanks before each correct characteristic.

_____ a. Use approved devices and oxidation inhibitors when connected copper to aluminum

_____ b. Provide full contact

_____ c. Are made with magnetic screwdriver

_____ d. Are tight

_____ e. Require no tools for installation

_____ f. Are clean

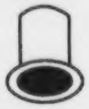
_____ g. Provide quick disconnect

_____ h. Show bright terminal connection

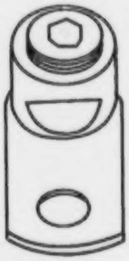
_____ i. Are strong

Objective 4

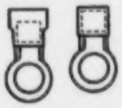
Identify the following types of connectors, terminals, and lugs. Write the correct names in the blanks.



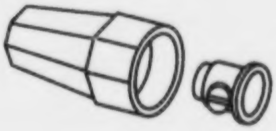
a. ______________________________



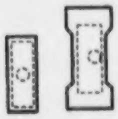
b. ______________________________



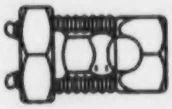
c. ______________________________



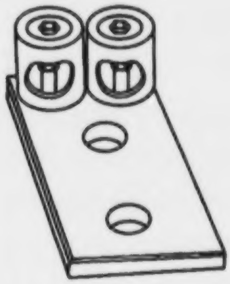
d. ______________________________



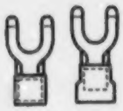
e. ______________________________



f. ______________________________

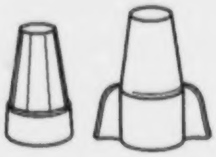


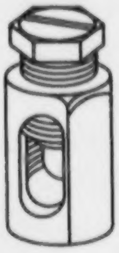
g. ______________________________



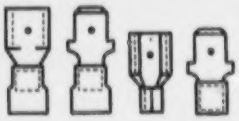
h. ______________________________

Written Test





i. ______________________ j. ______________________



k. ______________________

Objective 5

Match the letter designations for wire insulation with their correct characteristics.

1. HH 3. T 5. N 7. H
2. W 4. No H 6. -2

_____ a. Nylon outer cover

_____ b. Thermoplastic insulation

_____ c. 90° C insulation rating

_____ d. 75° C insulation rating

_____ e. Suitable for 90° C in wet locations

_____ f. Damp or wet

_____ g. 60° C insulation rating

Objective 6

Identify types of insulation, given its characterisitcs, applications, and code letters. Write the correct insulation names in the left-hand column.

Insulation Type	*Code* Letters	Application	Characteristics
a.	TW	Dry and wet locations	Flame retardant; moisture resistant; no outer covering
b.	THHN	Dry and damp locations	Flame retardant; heat resistant; nylon jacket
c.	THHW	Wet and dry locations	Flame retardant; moisture- and heat-resistant; no outer covering
d.	MTW	Machine tool wiring in wet locations as permitted in NFPA Standard No. 79 (See Article 670.) Machine tool wiring in dry location as permitted in NFPA Standard No. 79 (See Article 670.)	Flame retardant; moisture, heat, and oil resistant; wet applications, no outer covering; dry applications, nylon jacket
e.	THW	Dry and wet locations Special applications within electric discharge lighting equipment; limited to 1,000 open-circuit volts or less (size 14-8 only as permitted in Section 410-31)	Flame retardant; moisture and heat resistant; no outer covering
f.	THWN	Dry and wet locations	Flame retardant; moisture and heat resistant; nylon jacket

Written Test

Objective 7

Complete statements about color codes for conductors. Write in the blanks, the color that best completes each description.

a. 120/240V, 1-phase: __________, Red, White

b. 120/240V, 3-phase (with high leg conductor): Black, __________, Blue,

White

c. Grounded conductor: ____________ or Gray

d. 480Y/277V: Brown, Orange, ____________, Gray

e. 208Y/120V: Black, ____________, Blue, White

f. Equipment grounding conductor: Bare or ____________

Objective 8

Complete statements concerning the means of identifying "grounded" and equipment "grounding" conductors. Write in the blanks, the word(s) that best completes each statement.

a. Equipment grounding conductors shall be permitted to be ____________________, ____________________, or ____________________.

b. An insulated grounded conductor of #6 or smaller shall be identified by a continuous ____________________ or natural ____________________ outer finish or by three continuous white stripes on other than green insulation along its entire length.

c. An insulated or covered conductor larger than #6 copper or aluminum shall be permitted, at the time of installation, to be permanently identified as an equipment grounding conductor at each end by coloring the exposed insulation or covering ____________________.

d. An insulated grounded conductor larger than #6 can be identified at the time of installation by a distinctive ____________________ marking at its termination. This marking shall encircle the conductor or insulation.

Objective 9

List three conductors commonly found in electrical wiring.

a. ____

b. ____

c. ____

Objective 10

Match with their uses, types of cables found in the electrical field. Write the correct numbers in the blanks.

1. Nonmetallic-sheathed (NM and NMC)
2. Underground feeder and branch circuit (UF)
3. Service-entrance (SE and USE)
4. Armored (AC)
5. Mineral insulated, metal-sheathed (MI)
6. Power and control tray (TC)

_____ a. Dry and wet locations; suitable for burial

_____ b. Dry locations; used in majority of residential interior wiring

_____ c. Used for power, lighting, control, signal, and communication circuits

_____ d. Dry and wet locations; used for services, feeders, and branch circuits

_____ e. Dry locations; used for branch circuits and feeders in both exposed and concealed work

_____ f. Dry and wet locations; used for service-entrance conductors where applicable

Objective 11

Select true statements about cords and their conductors. Write an "X" in the blank before each true statement.

_____ a. Cords used in a grounded system must have an identified grounded conductor.

_____ b. Cords that have a conductor with red or red with yellow striped insulation shall use that conductor for grounding only.

_____ c. Ungrounded conductors can be any color that is designated for grounded or grounding conductors.

_____ d. Cords should be used within their amp and insulation rating or classification.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 1
b. 6
c. 7
d. 4
e. 5
f. 10
g. 9
h. 2
i. 3
j. 8
k. 11
l. 16
m. 15
n. 14
o. 12
p. 17
q. 13

Objective 2

a. Full load amperes
b. Number of conductors
c. Type of load served
d. Length of run
e. Ambient temperature
f. Voltage

Objective 3

a, b, d, f, i

Objective 4

a. Crimp sleeve connector
b. Single terminal
c. Ring lugs
d. Set-screw lug
e. Crimp-type butt connectors
f. Split bolt lug
g. Twin or double terminal
h. Spade connectors
i. Wire nut lugs
j. Service entrance lug
k. Quick disconnect connector

Objective 5

a. 5
b. 3
c. 1
d. 7
e. 6
f. 2
g. 4

Objective 6

a. Moisture-resistant thermoplastic
b. Heat-resistant thermoplastic
c. Moisture- and heat-resistant thermoplastic
d. Moisture-, heat-, and oil-resistant thermoplastic
e. Moisture- and heat-resistant thermoplastic
f. Moisture- and heat-resistant thermoplastic

Answers to Written Test

Objective 7

a. Black
b. Orange
c. White
d. Yellow
e. Red
f. Green

Objective 8

a. Bare, covered, insulated
b. White, gray
c. Green
d. White

Objective 9

a. Copper
b. Aluminum
c. Copper-clad aluminum

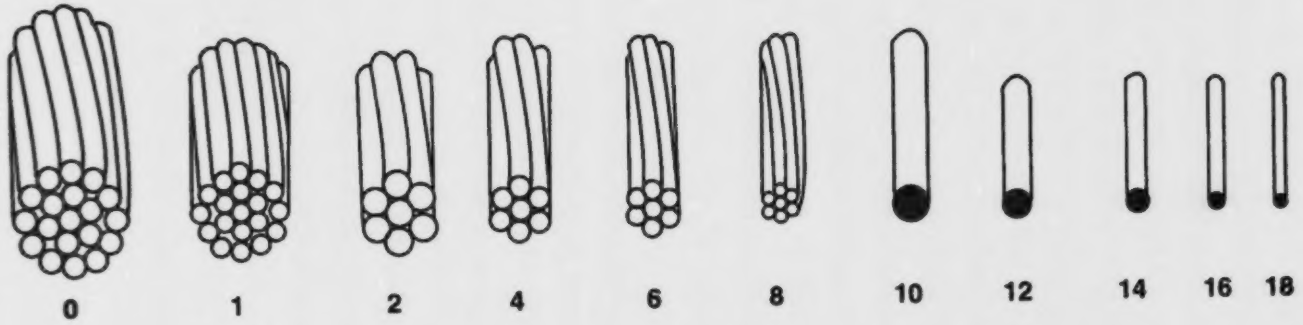
Objective 10

a. 2
b. 1
c. 6
d. 5
e. 4
f. 3

Objective 11

a, d

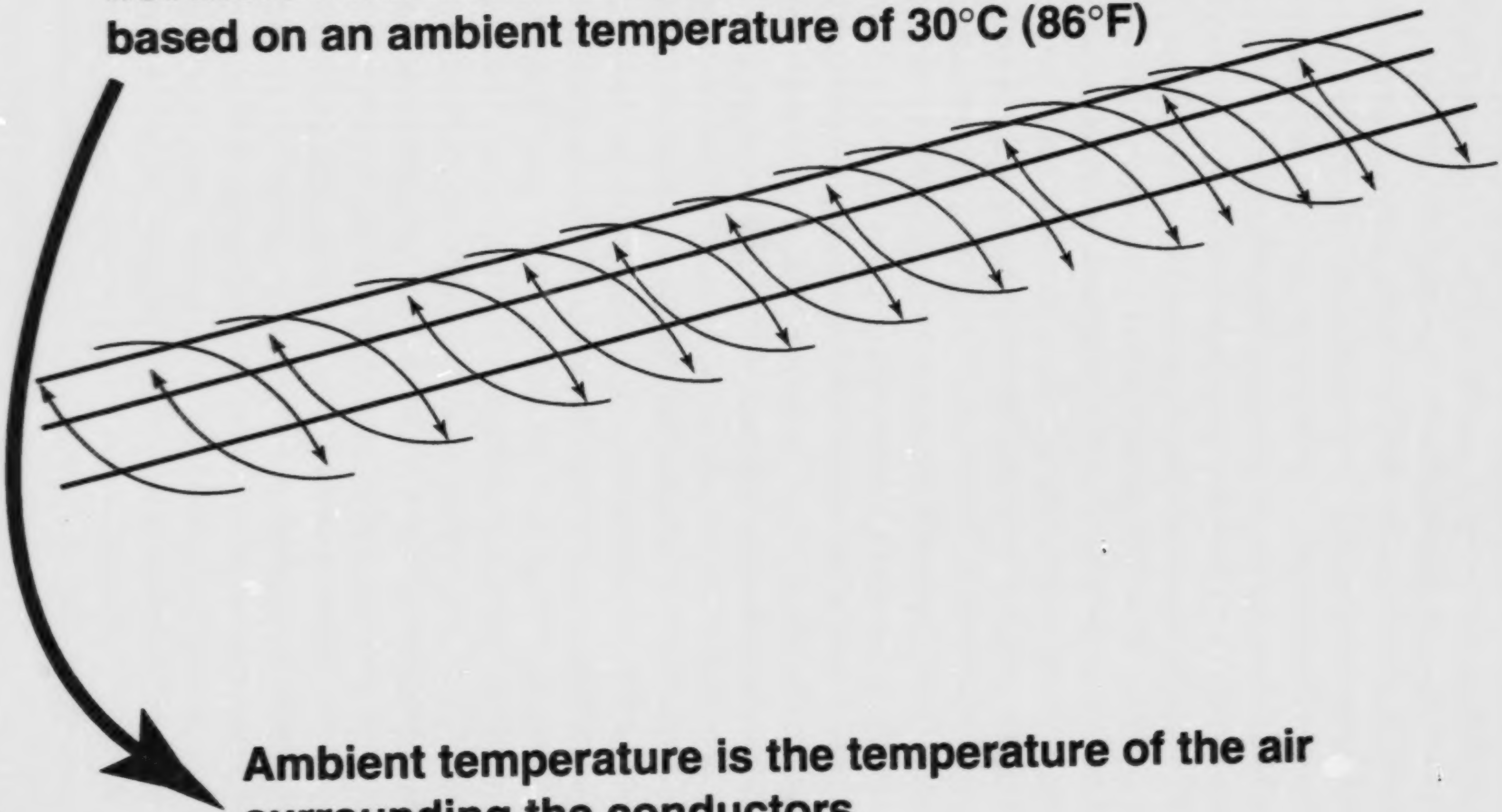
AWG Conductor Sizes


0
1
2
4
6
8
10
12
14
16
18

Actual Diameters of
Typical Sizes of Electric Wires Without Insulation

Ambient Temperature

Table 310-16: "Allowable ampacities of insulated conductors, not more than three conductors in a raceway or cable", is based on an ambient temperature of 30°C (86°F)



Ambient temperature is the temperature of the air surrounding the conductors.

Overcurrent Protection

The maximum overcurrent protection for certain conductor wire sizes are required to be as stated in section 240.4(D) and are indicated by an asterik (*) in Table 310.16.

Copper	**Aluminum or Copper Clad Aluminum**
• #14 AWG-15 amp	• #12 AWG-15 amp
• #12 AWG-20 amp	• #10 AWG-25 amp
• #10 AWG-30 amp	

Unit 14 Low Voltage Wiring

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 14–3

Answers to Assignment Sheets 14–9

Written Test 14–11

Answers to Written Test 14–19

Transparency Masters

1—Low Voltage Off/On Switching Cycle 14–23
2—Thermostat: Manual Fan Control 14–25
3—Thermostat: Cooling Circuit with Automatic Fan Control 14–27
4—Thermostat: Heating Circuit with Automatic Fan Control 14–29
5—Smoke Detector: Interconnect Wiring Diagram 14–31

Student Components

Student Page

Learning Activities Sheet 14–3

Objective Sheet 14–5

Information Sheet 14–7

* Focus Assignment

List Licensing Requirements for Low Voltage Wiring Systems 137

* Assignment Sheets

1—Draw a Wiring Diagram Indicating the Proper Connection for Bell Circuit Equipment 139
2—Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors 141

* Job Sheets

1—Wire a Two-Button Chime Circuit 143
2—Wire Two Interconnecting Smoke Detectors 149

* Focus Assignment, Assignment Sheets and Job Sheets are located in Student Workbook 2.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Low Voltage Off/On Switching Cycle (Objective 3)
  TM 2—Thermostat: Manual Fan Control (Objective 5)
  TM 3—Thermostat: Cooling Circuit with Automatic Fan Control (Objective 6)
  TM 4—Thermostat: Heating Circuit with Automatic Fan Control (Objective 7)
  TM 5—Smoke Detector: Interconnect Wiring Diagram (Objective 10)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.

Suggested Activities

- Discuss unit and specific objectives.

- Have students complete the focus assignment to introduce topics presented in unit of instruction.

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Contact a local sales distributor to visit the class and demonstrate low voltage lighting and signaling devices.

- Assign students to write a report on the advantages and disadvantages of low voltage lighting. Discuss student reports in class.

- Contact a local telephone company representative to visit the class and demonstrate phone systems. Discuss local requirements for installation of the equipment and system.

- Contact a local C.A.T.V. (Community Antenna Television) cable system to visit the class and discuss the local requirements for installation of equipment and the connection to their system.

- Plan an outside field trip to local phone company and C.A.T.V. cable system switching locations.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

Suggested Activities

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used In Developing This Unit

Print Media

- Foley, Joseph H. *Electrical Wiring Fundamentals.* New York: Gregg McGraw-Hill Book Company.
- Holzman, Harvey N. *Modern Residential Wiring.* South Holland, IL: Goodheart-Wilcox Company, Inc., 1986.
- Mullin, Ray C. *Electrical Wiring: Residential*, Eighth Edition. Albany, NY: Delmar Publishers, Inc., 1984.

Taylor, Mark. *Residential Wiring*, Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Supplemental Resources

Print Media

- *National Electrical Code, 2002*. Quincy, MA: National Fire Protection Association, 2001.
- *2002 NEC Analysis of Changes*. Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC
- *NEC 2002 Handbook*. Quincy, MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics
- *NFPA 72, National Fire Alarm Code*. Quincy, MA: National Fire Protection Association, 1996.

  The publication(s) listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org
- Early, Mark W., et al. *Illustrated Changes in the National Electrical Code*. Delmar Publishers, Inc. 2002.

  Provides a detailed view of the most important changes in the 2002 NEC
- Catalog—Hunzicker Brothers Catalog, 501 N. Virginia, Oklahoma City, OK 73125.
- Loyd, Richard. *Electrician's Technical Reference: Wiring Methods*. Delmar Publishers, Inc. 1999.
- Miller, Chris. *Illustrated Guide to the National Electrical Code*, 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type of occupancy, and contains 600 illustrations

- Mullin, Ray. *House Wiring with the National Electrical Code*, 11th ed. Delmar Publishers, Inc. 1999.

  Covers everything from lighting branch circuits, to small and large appliance branch circuits

- O'Riley, Ronald. *Electrical Grounding*, 6th ed. Delmar Publishers, Inc. 2002.

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code*, 6th ed. Delmar Publishers, Inc. 2002.

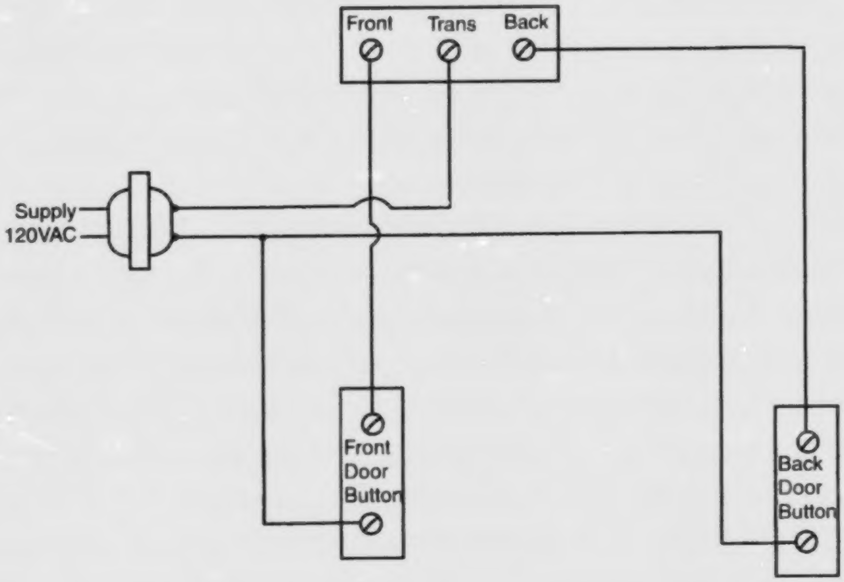
  Offers practical examples to illustrate how articles in the Code are applied

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers*, 2nd ed. Delmar Publishers, Inc. 2002.

Answers to Assignment Sheet

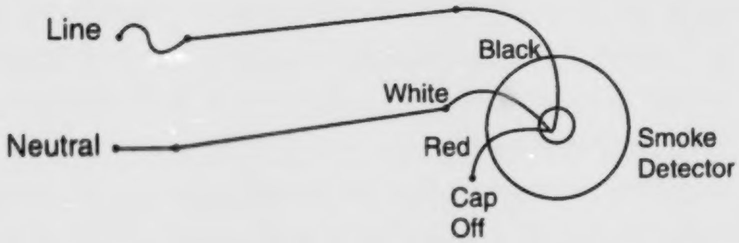
Assignment Sheet 1

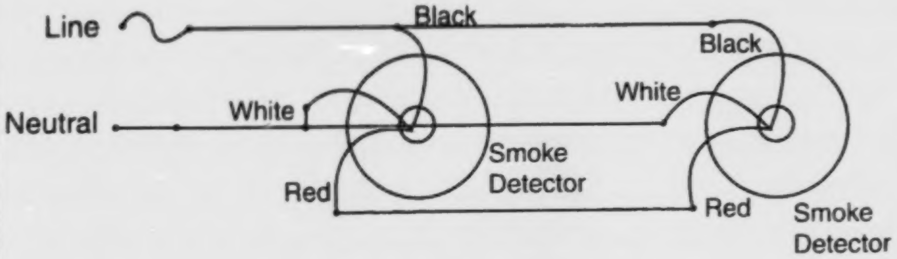
Draw a wiring diagram indicating the proper connection for bell circuit equipment


Front
Trans
Back
Supply
120VAC
Front Door Button
Back Door Button

Assignment Sheet 2

Draw a diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors


Line
Black
White
Neutral
Red
Smoke Detector
Cap Off


Line
Black
Black
White
White
Neutral
Smoke Detector
Red
Red
Smoke Detector

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their correct definitions. Write the correct numbers in the blanks.

1. Coaxial cable	6. Smoke detector
2. Heat detector	7. Solenoid
3. Momentary contact switch	8. Telephone system
4. Pull-push solenoid	9. Thermostat
5. Relay	10. Transformer

_____ a. A device that senses temperature variations from a set point and, in turn, acts to control a circuit

_____ b. Electromagnetic device for remote or automatic control

_____ c. Electromagnetic cylinder that moves an iron plunger when current is applied

_____ d. Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has circuits applied to it

_____ e. A switch that is closed or opened only while the operator touches it

_____ f. An electrical device used to step up or step down a primary voltage to a desired secondary voltage

_____ g. A fire warning device commonly used in a residence; available in two types: photoelectric or ionization

_____ h. A personal communication system installed in the home to provide outside conversation with the world

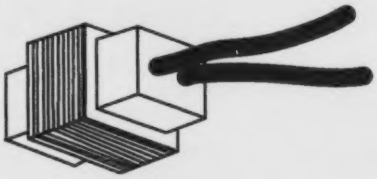
_____ i. A fire warning device commonly used in a residence; available in two types: fixed or rate-of-rise temperature detectors

_____ j. Conductor used for carrying communication signals

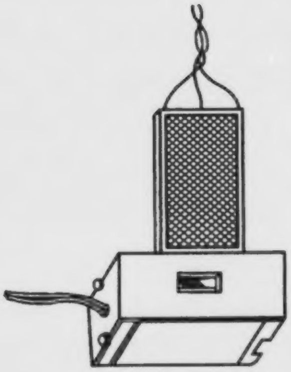
Written Test

Objective 2

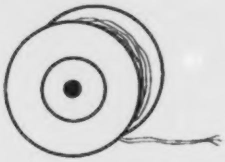
Identify the parts of a low voltage wiring system. Write your answers in the blanks provided.



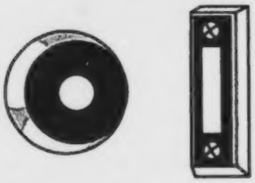
a. ______________________



b. ______________________



c. ______________________



d. ______________________

Objective 3

Describe the process that takes place during a low voltage lighting circuit off/on cycle.

"On" switch is pushed:

(1) ____

(2) ____

"Off" switch is pushed:

(1) ____

(2) ____

Objective 4

Describe the process that takes place during the energizing of a chime circuit.

Button is pushed:

(1) ____

(2) ____

Button is released:

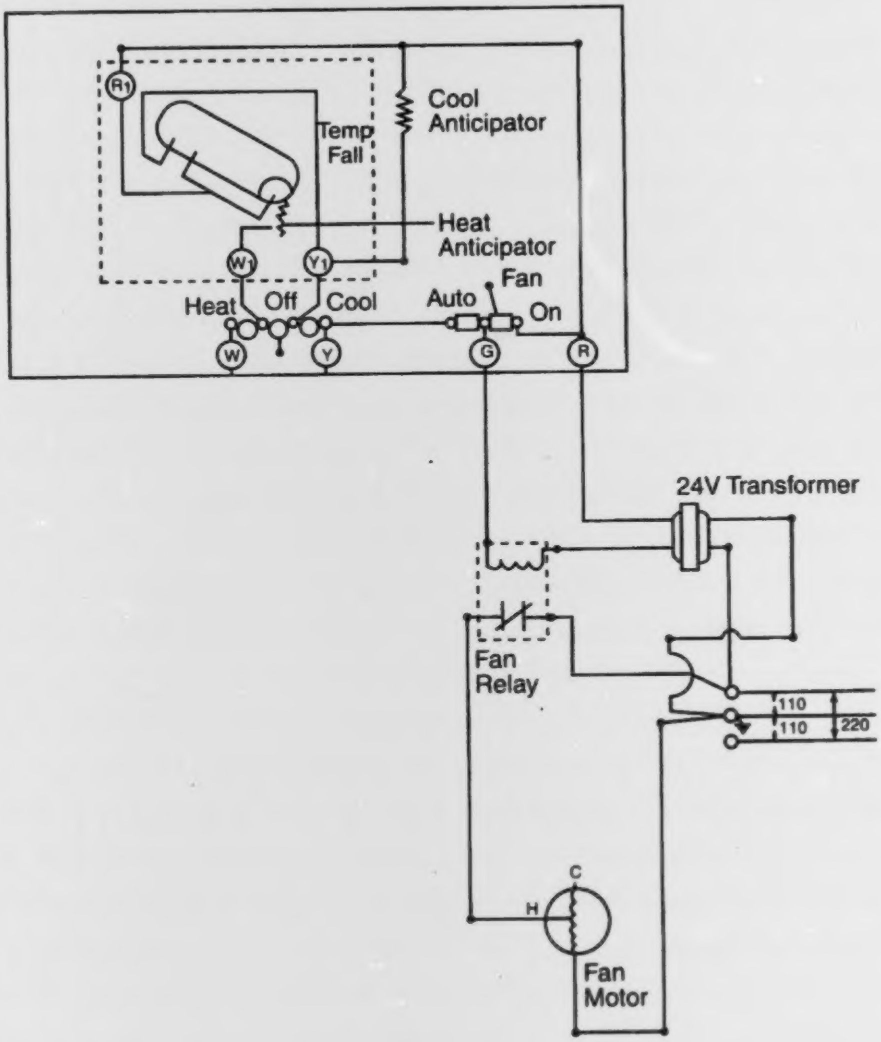
(1) ____

(2) ____

Objective 5

Complete a thermostat drawing of the manual fan switching circuit below to indicate the current flow path through the fan control switch and fan relay.

Note: Let → → → indicate current flow.

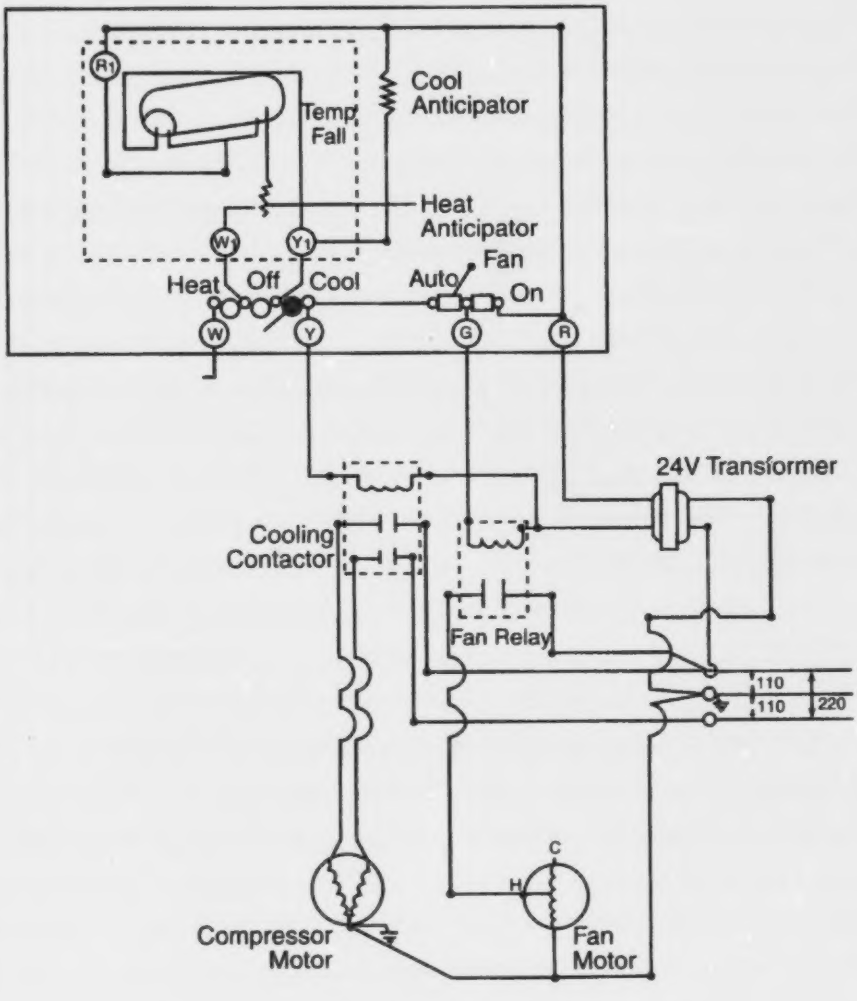

R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

Written Test

Objective 6

Complete the thermostat drawing below to indicate the current flow path with the thermostat system switch in the cool position and the fan switch on auto.

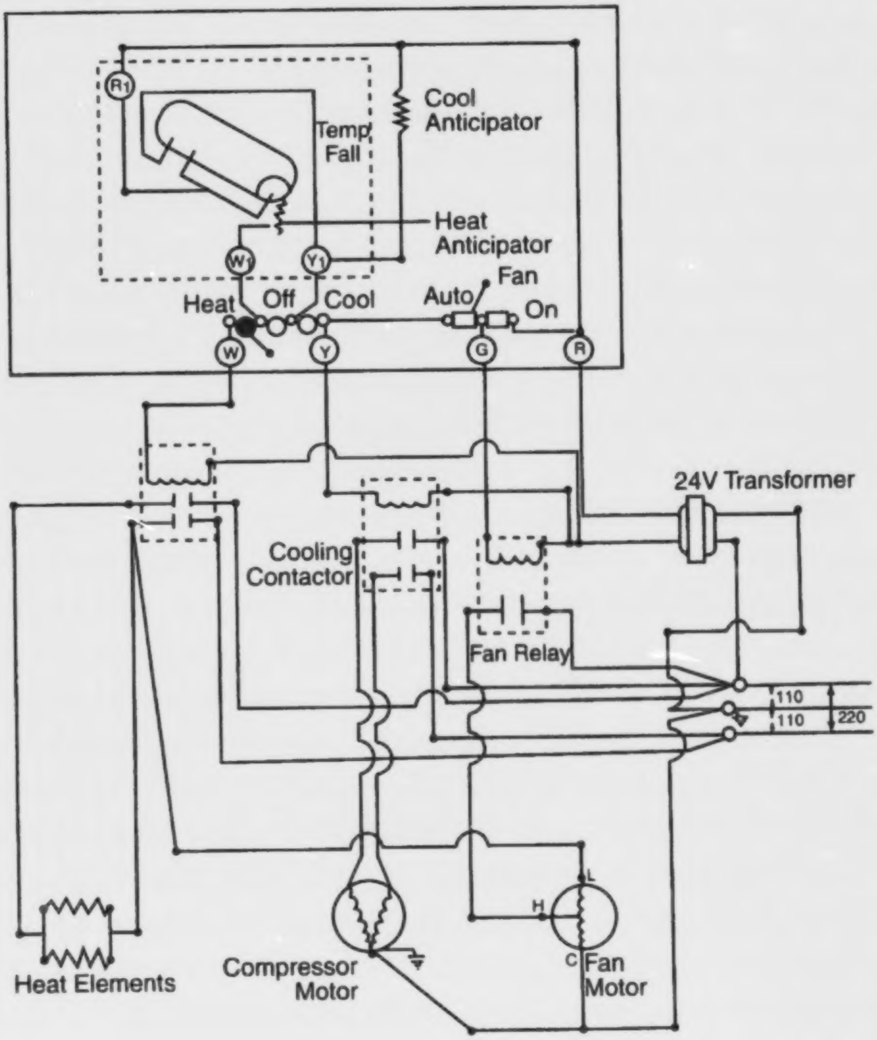
Note: Show both fan and cooling relays closed.


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

Objective 7

Complete the thermostat drawing below to indicate the current flow paths with the thermostat system switch in the heat position and the fan switch on auto.

Note: Show heat relay closed


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Fan
Auto
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

Written Test

Objective 8

Complete statements concerning anticipator circuits on low voltage thermostats. Write in the blanks the word(s) that best completes each statement.

a. Heat and cool anticipators are installed to compensate for ______________________.

b. Cool anticipator

(1) It is wired ______________________ to mercury switch.

(2) Heat causes bimetal to tilt bulb and ______________________ circuit before room temperature actually reaches "on" temperature setting.

c. Heat anticipator

(1) It is wired ______________________ to mercury switch.

(2) Heat causes bimetal to tilt bulb and ______________________ circuit before room temperature reaches desired room setting.

Objective 9

Match the terms with their correct definitions. Write the correct numbers in the blanks.

1. Intercom
2. Television antenna
3. Telephone

_____ a. The point where the wiring ends and the home owner's interior wiring begins is called the "demarkation point."

_____ b. The circuit wiring is installed on two pair, 4-conductor, cable.

_____ c. This low voltage wiring system allows room-to-room two-way conversation in a residence.

_____ d. The cable types in this system are 300 ohm or 75 ohm.

_____ e. This system requires a separate pair of conductors all the way back to the company's switching center.

_____ f. This system may incorporate radio and tape playing with room temperature.

Objective 10

Complete statements concerning smoke and fire alarm systems. Write in the blanks the word(s) that best complete each statement.

a. Fire warning devices commonly used in a residence are a ____________________ and a ____________________ detector.

b. ____________________ detectors sense a specific fixed temperature a rate-of-rise.

c. The two most common types of smoke detectors are the ____________________ type and the ____________________ type.

d. ____________________ is the third leading cause of accidental fatalities.

Objective 11

Select true statements concerning the operation of a garage door opener by placing an "X" in the blanks next to the true statements.

_____ a. The opener contains a motor, radar controller, motor reversing switch, keynote speaker, radio operated controller, and electric brake.

_____ b. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers.

_____ c. The push-button or key operated station consists of a normally open momentary contact switch connected by 4-wire low voltage cable to the control unit. A photoelectric sensor system is also conencted to the control unit by low voltage cable to insure a clear path for the door to travel.

_____ d. The radio-controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency, it will energize the motor in the opposite direction of its previous travel.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	9	d.	4	g.	6	j.	1
b.	5	e.	3	h.	8		
c.	7	f.	10	i.	2		

Objective 2

a. Transformer
b. Low voltage lighting relay
c. Low voltge cable
d. Momentary contact switch

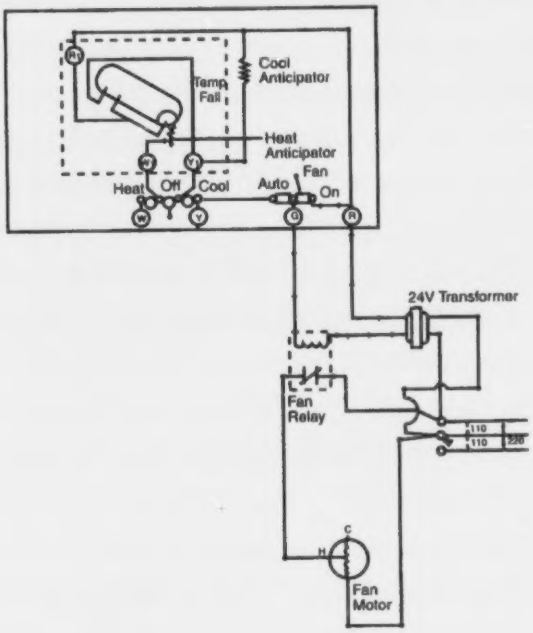
Objective 3

a. “On” switch is pushed
  (1) Circuit is completed to closing movement fo solenoid in relay
  (2) Core is moved and circuit is completed
b. “Off” Switch is pushed
  (1) Circuit is completed to opening movement of solenoid in relay
  (2) Core is moved and circuit is opened

Objective 4

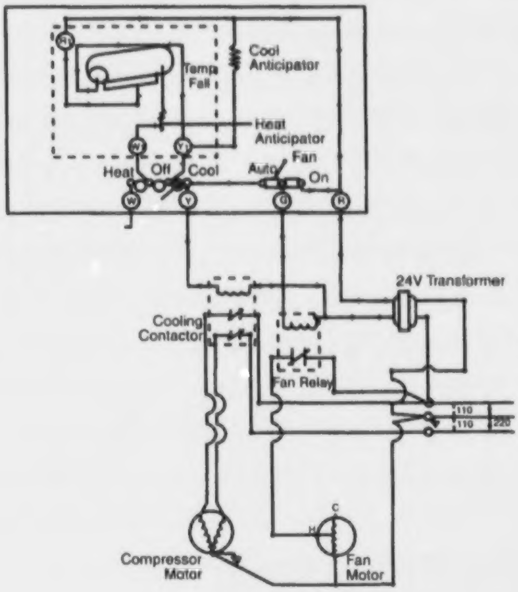
Description should include:
a. Button is pushed
  (1) Circuit is completed to solenoid
  (2) Plunger is drawn down to chime and sound is made
b. Button is released
  (1) Circuit is open
  (2) Spring pulls plunger up to upper chime and another sound is made

Objective 5

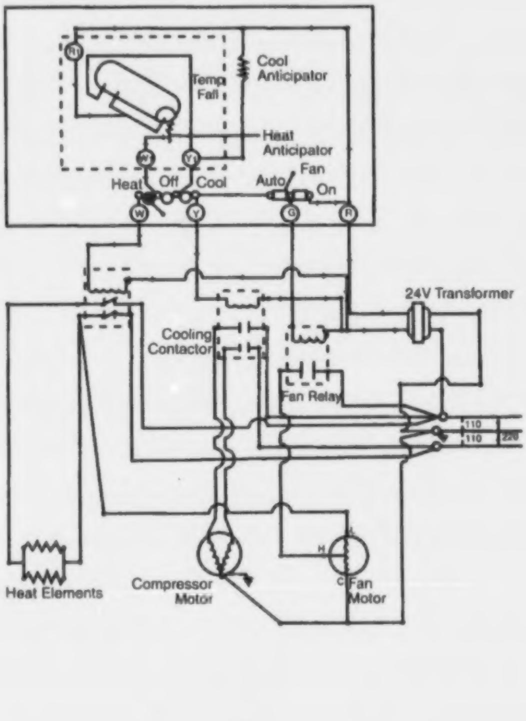

R
Temp Fall
Cool Anticipator
Heat Anticipator
W
Y
Heat
Off
Cool
Fan
Auto
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

Answers to Written Test

Objective 6


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Heat
Off
Cool
Auto
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
Compressor Motor
C
H
Fan Motor

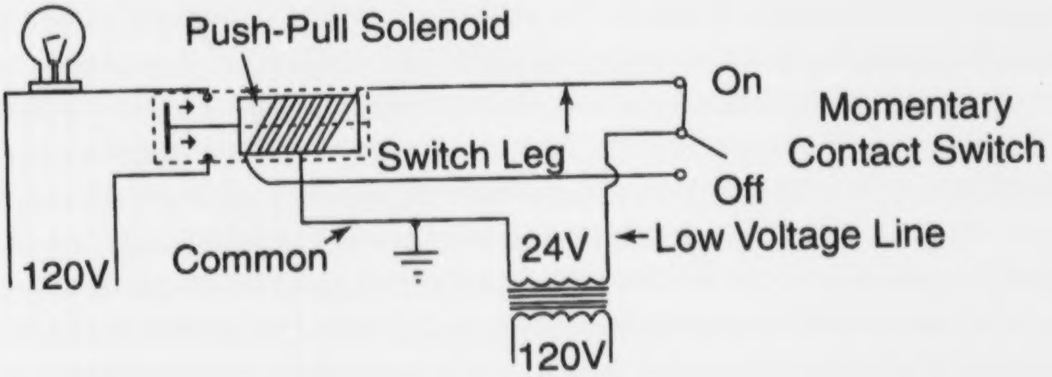
Objective 7

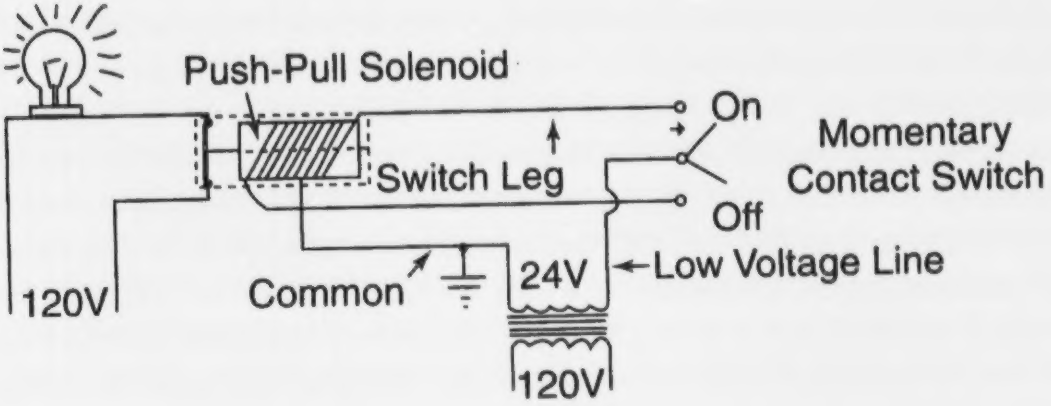

R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Heat
Off
Cool
Auto
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
Heat Elements
Compressor Motor
H
C
Fan Motor

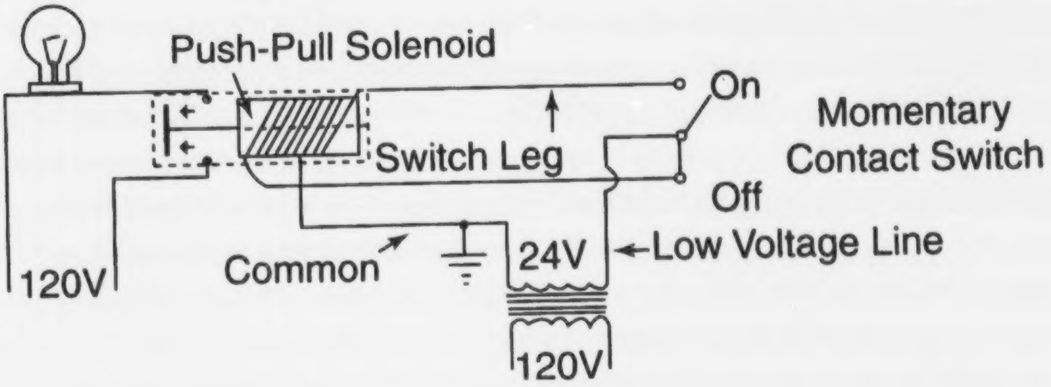
Answers to Written Test

Objective 8	a. Bimetallic lag b. (1) Parallel (2) Close c. (1) In series (2) Open
Objective 9	a. 3 b. 3 c. 1 d. 2 e. 3 f. 1
Objective 10	a. Heat, smoke b. Heat c. Photoelectric, ionization d. Fire
Objective 11	b, d

Low Voltage Off/On Switching Cycle


Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V

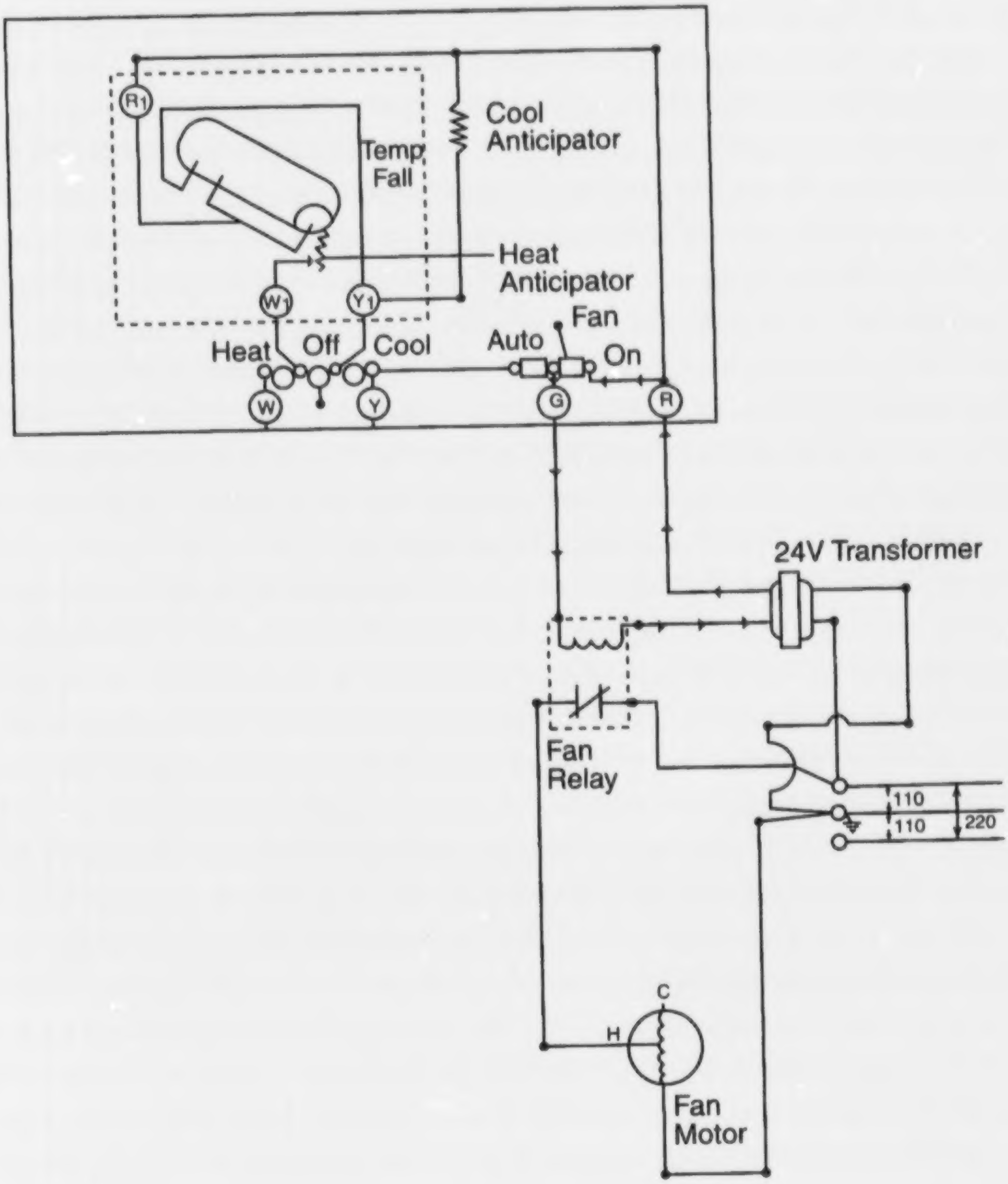

Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V


Push-Pull Solenoid
On
Momentary
Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V

TM 1

T 14–23

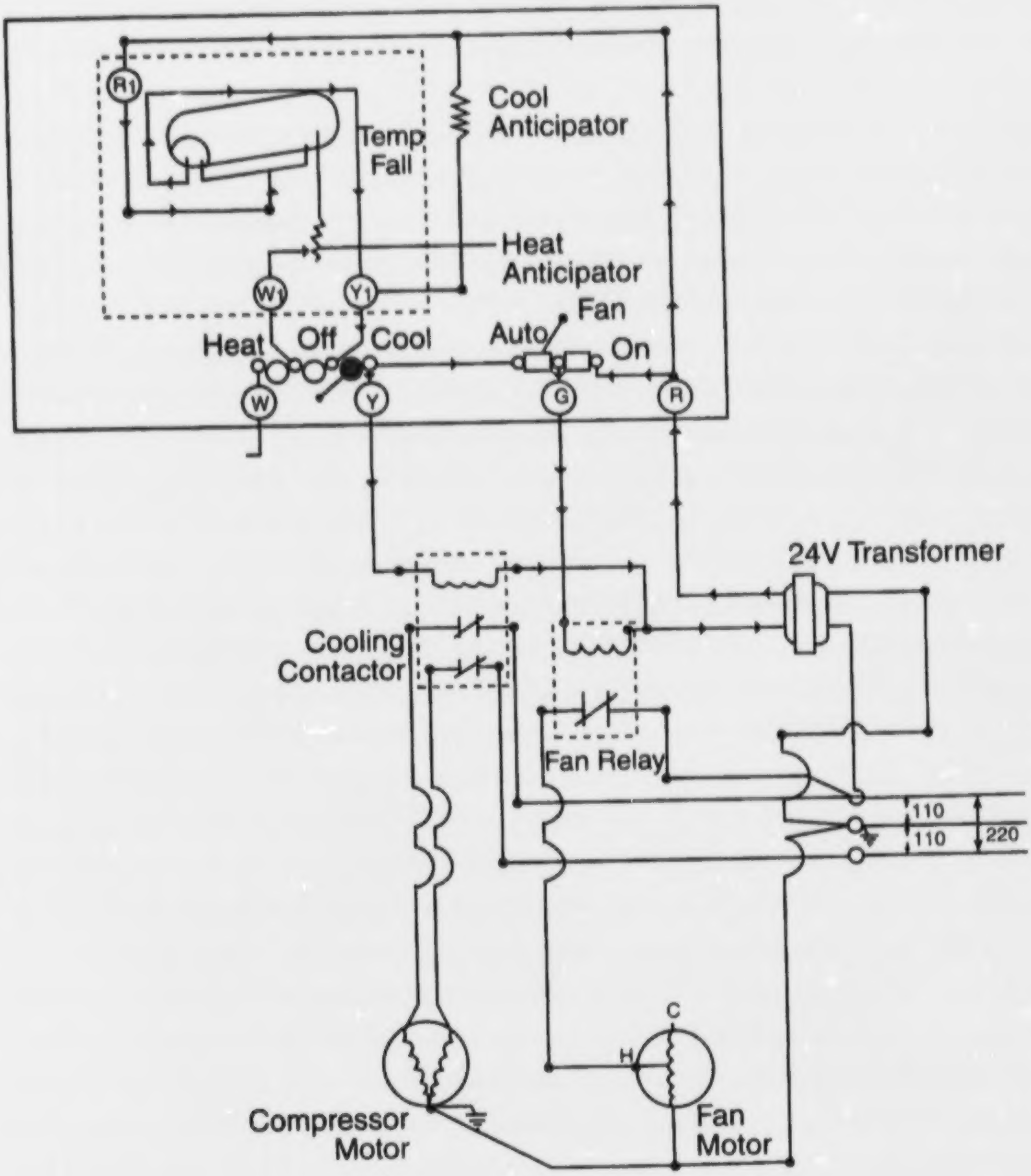
Thermostat: Manual Fan Control


R1
Cool Anticipator
Temp Fall
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

TM 2

T 14–25

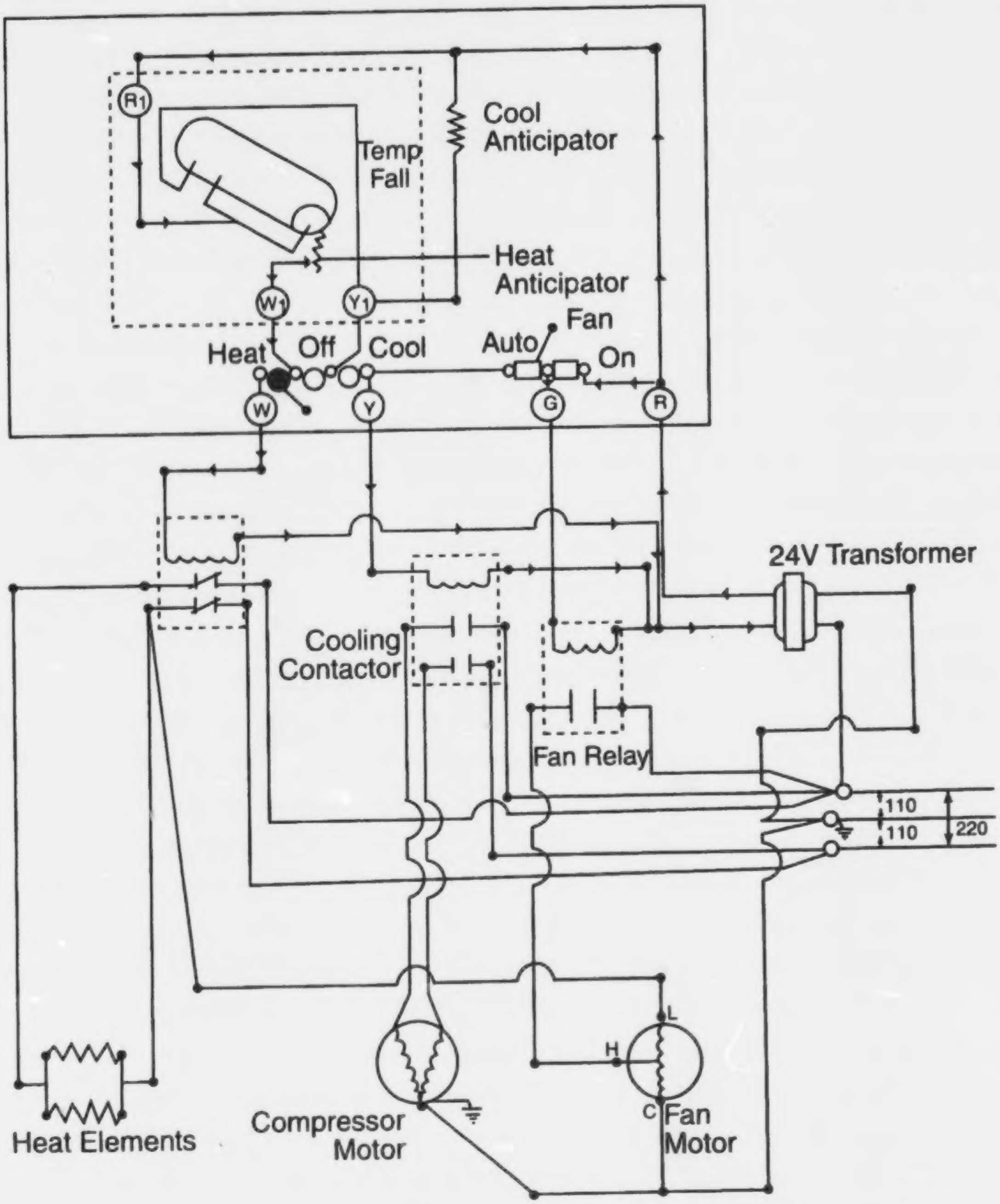
Thermostat: Cooling Circuit with Automatic Fan Control


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Auto
On
Heat
Off
Cool
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

TM 3

T 14–27

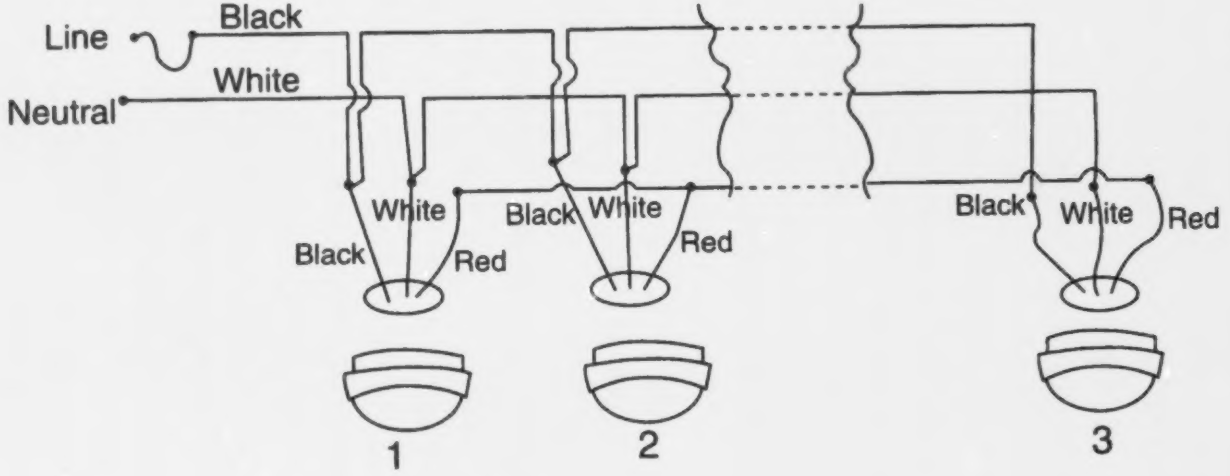
Thermostat: Heating Circuit with Automatic Fan Control


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Auto
On
Heat
Off
Cool
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

TM 4

T 14-29

Smoke Detector: Interconnect Wiring Diagram


Line
Neutral
Black
White
Black
White
Red
Black
White
Red
Black
White
Red
1
2
3

Unit 15

Overcurrent Protection

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 15–3

Answers to Assignment Sheets 15–9

Written Test 15–11

Answers to Written Test 15–15

Teacher Supplement

1—Design Plan for Overcurrent Protection Display 15–17

Transparency Masters

1—Selective Coordination 15–19
2—Fuse Elements 15–21
3—Time-Current Curve Average Melt for One-Time General Purpose NON (Single-Element Fuse) 15–23
4—Time-Current Average Melt for Dual-Element Time-Delay FRN-R & FRS-R 15–25
5—Ground Fault Relaying 15–27

Student Components

Student Page

Learning Activities Sheet 15–3

Objective Sheet 15–5

Information Sheet 15–7

* Focus Assignment

Identify Overcurrent Protective Devices 153

* Assignment Sheet

1—Calculate Conductor and Fuse Sizes 155

* Job Sheet

1—Test Cartridge Fuses 157

* Focus Assignment, Assignment Sheet and Job Sheet are located in Student Workbook 2.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM 1—Selective Coordination (Objective 1)
TM 2—Fuse Elements (Objective 2)
TM 3—Time-Current Curve Average Melt for One-Time General Purpose NON (Single-Element Fuse) (Objective 3)
TM 4—Time-Current Curve Average Melt for Dual-Element Time-Delay FRN-R & FRS-R (Objective 3)
TM5—Ground Fault Relaying (Objective 8)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Display overcurrent protective devices and have students write down the name of the device, and at least one application they believe it may be used for (Focus Assignment)
- Use the design plan in Teacher Supplement 1 to construct a display to demonstrate the need for proper overcurrent protection.
- Invite a Buss fuse representative to speak to the class.
- Show cutaways of each type of breaker and fuse.
- Arrange a field trip to a local electrical supply house to view varied types of overcurrent protective devices.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- *Buss Full Line Catalog (FLC)*. Bussmann Division, McGraw-Edison Co., 1985.
- *Maintenance of Low Voltage Circuit Breakers and Switch Gear*. Rockville, MD: NUS Training Corporation, a Haliburton Company.
- Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.
- *National Electrical Code, 2002*. Quincy, MA: National Fire Protection Association, 2001.
- Stallcup, James G. *Illustrated Changes of the 1993 NEC*. Homewood, IL: American Technical Publishers, Inc., 1992.
- Taylor, Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- Teague, Cash and Garner Pewewardy. *Industrial Electricity: In-Plant Distribution*. Stillwater, OK: Oklahoma Curriculum and Instructional Materials Center, 1984.
- *National Electrical Code, 1999*. Quincy, MA: National Fire Protection Association, 1998.

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes*. Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC

- *NEC 2002 Handbook*. Quincy, MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics

The publication(s) listed above can be ordered from:

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02269-9101
1-800-344-3555
www.nfpa.org

- Early, Mark W., et al. *Illustrated Changes in the National Electrical Code.* Delmar Publishers, Inc. 2002.

  Provides a detailed view of the most important changes in the 2002 NEC

- Leviton Catalog, Leviton Mfg. Co. Inc., 59-25 Little Neck Pkwy, Little Neck, NY 11362. 1-800-824-3005. www.leviton.com

- Loyd, Richard. *Electrician's Technical Reference: Wiring Methods.* Delmar Publishers, Inc. 1999.

- Miller, Chris. *Illustrated Guide to the National Electrical Code,* 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type or occupancy, and contains 600 illustrations

- O'Riley, Ronald. *Electrical Grounding,* 6th ed. Delmar Publishers, Inc. 2002.

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code,* 6th ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.

Electronic Media

- Bussmann Fuse Catalog. www.bussmann.com

- Ground Fault Circuit Interrupter (11 minutes). Trains the employees in the use of GFCI's and how the system operates.

  Note: Order video from MAVCC, 1500 West Seventh Avenue, Stillwater, OK 74074-4364, e-mail at mavccweb@okvotech.org, visit their web site at www.mavcc.org, or call (800) 654-3988.

Answers to Assignment Sheets

Assignment Sheet 1

Calculate Conductor and Fuse Sizes

1. #1THW copper conductor
2. 60 amp dual element fuse
3. #16 THHN copper conductor; 35 amp dual element fuse
4. #8 THHN copper conductor; 100 amp inverse time breaker

Written Test

Name ______________________________________

Date ______________________________ Score__________

Objective 1

Match terms related to overcurrent protection with their definitions. Definitions continue on the next page.

1. Air circuit breaker
2. Amperage rating
3. Blade-type cartridge fuse
4. Circuit breaker
5. Current-limiting over-current protective device
6. Device
7. Dual-element fuse
8. Edison-base plug fuse
9. Fault current
10. Ferrule-type cartridge fuse
11. Ground fault
12. Ground-fault circuit interrupter
13. Interrupting rating
14. Oil circuit breaker
15. Overcurrent
16. Overload
17. Selective coordination
18. Single-element fuse
19. Time-current curve
20. Type "S" plug fuse
21. Voltage rating
22. Arc-fault circuit interputer

_____ a. Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

_____ b. Maximum voltage at which a device is designed to operate

_____ c. Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating.

_____ d. Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

_____ e. Fuse that contains only one element and is not designed to carry on overload

_____ f. Fuse that has within it a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without harming the fuse

_____ g. The use of interrupting devices sized and installed so that the one nearest the fault or overloaded machine will open before any of the larger upstream devices open

_____ h. Maximum current-carrying capacity of a device

_____ i. Breaker in which all parts operate in air

_____ j. Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

_____ k. A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating

_____ l. Fuse with special size-limiting characteristics for each amperage range

_____ m. Fuse with flat contact blades on a cylindrical case

_____ n. A unit of an electrical system that is intended to carry but not utilize electric energy.

_____ o. Fuse with a base that fits the same socket as a regular based incandescent bulb

_____ p. Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

_____ q. Fuse with metal caps on a cylindrical case

_____ r. A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time, when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

_____ s. Maximum available short-circuit current that an overcurrent device can safely interrupt without damage to itself

_____ t. Load interrupter in which the interrupting contacts operate submerged in transformer oil

_____ u. Any current in excess of the rated current of the equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

_____ v. A device intended to provide protection from the effects of faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when a fault is detected.

Objective 2

List eight types of overcurrent protective devices.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

Objective 3

Describe the operation of a single-element fuse.

____

____

____

Objective 4

Describe the operation of a dual-element, time-delay fuse.

____

____

____

Objective 5

Distinguish between types of circuit breakers and their operation. Write a "T" for thermal trip next to its correct operation.

_____ a. As current flows through the breaker, it creates a magnetic field within the coil. During sustained overload conditions, the magnetic field interferes and draws the core into the coil. The metal trip bar is attracted to the core forcing the latch to move, thus opening the contacts.

_____ b. If current flow exceeds the rated limit of the breaker, the bimetallic strip heats and bends. As the strip bends, the latching mechanism is tripped and the contacts open.

Objective 6

Select true statements about requirements for fuses of less than 600 volts. Write an "X" in the blank before each true statement.

_____ a. Plug fuses shall be used in circuits exceeding 125 volts between conductors.

_____ b. Fuses shall be marked with their amperage rating.

_____ c. Edison-base plug fuses shall be classified 0 to 20 amperes.

_____ d. Plug fuses may be used only as replacements.

_____ e. Type "S" fuses (fustats) shall be classified at not over 125 volts.

_____ f. Different ampere classes of Type "S" fuses are interchangeable.

_____ g. Cartridge fuses shall be marked with their ampere rating, voltage rating, and the name or trademark of the manufacturer.

Written Test

Objective 7

Complete statements concerning requirements for circuit breakers of less than 600 volts. Write in the blanks, the word(s) that best completes each statement.

a. Circuit breakers shall be capable of being manually ____________________ and ____________________.

b. Circuit breakers shall have a visible ____________________ and ____________________ indication.

c. The breaker shall be designed so that any change of its trip point (ampere rating) or time required for operation will require ____________________ or the breaking of a seal.

d. Circuit breakers shall be marked with their ampere rating in a manner that will be ____________________ and ____________________ by removal of a trim or cover.

e. Every circuit breaker having an interrupting rating other than ____________________ amperes shall have its interrupting rating shown on the circuit breaker.

Objective 8

List seven installations that require GFCI protection.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

Objective 9

List the installation requiring AFCI protection

a. ____

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 11
b. 21
c. 16
d. 20
e. 19
f. 7
g. 17
h. 2
i. 1
j. 5
k. 4
l. 18
m. 3
n. 6
o. 8
p. 9
q. 10
r. 12
s. 13
t. 14
u. 15
v. 22

Objective 2

a. Edison-base plug fuse
b. Type "S" plug fuse (fustat)
c. Ferrule-type cartridge fuse
d. Blade-type cartridge fuse
e. Circuit breaker
f. Ground-fault circiut interrupter receptacle
g. Ground-fault circiut interrupter breaker
h. Arc-fault circuit interrupter breaker

Objective 3

Under sustained overload conditions, the restricted portions of the fuse element heat to their predetermined melting point, thus opening and interrupting the flow of current.

Objective 4

Under sustained overload conditions, the trigger spring fractures the fusing alloy and releases the "S" connector.

Objective 5

b

Objective 6

b, d, e, g

Objective 7

a. Tripped, set
b. Off, on
c. Dismantling
d. Durable, visible
e. 5,000

Objective 8

Answer should include any seven of the following:

a. All 125-volt, single-phase 15- and 20-ampere receptacles that are not part of the permanent wiring on construction sites
b. All 125-volt, single-phase 15- and 20-ampere receptacles installed in bathrooms
c. All 125-volt, single-phase 15- and 20-ampere receptacles installed in garages
d. All 125-volt, 15- and 20-ampere receptacles installed outdoors where there is direct grade level

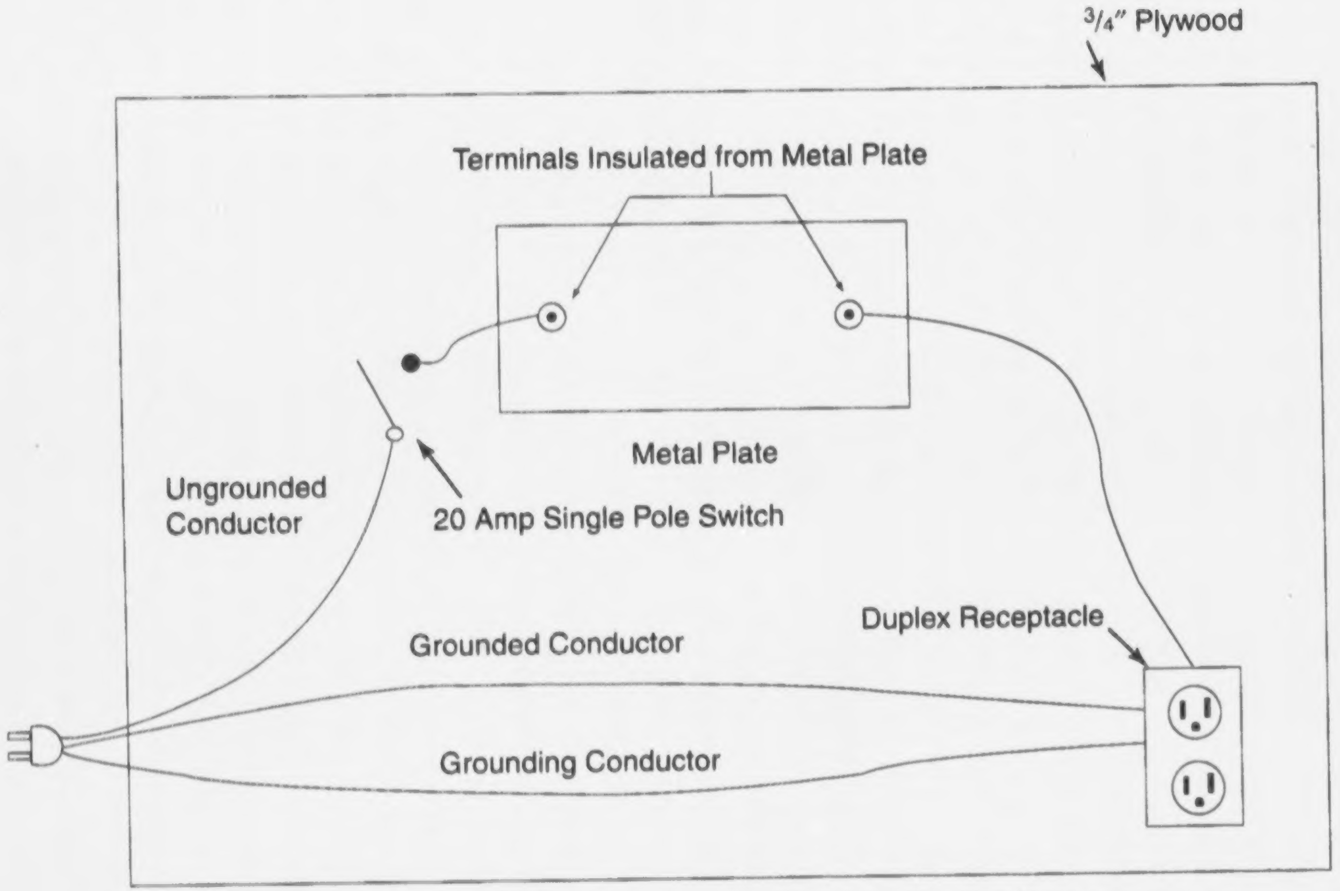
Answers to Written Test

e. All 125-volt, 15- and 20-ampere receptacles in crawl spaces at or below grade level and in unfinished basements
f. All 125-volt, 15- and 20-ampere receptacles within 6 feet of a wet bar sink or kitchen sink that serves counter top surfaces
g. All 125-volt, 15- and 20-ampere receptacles installed in boathouses
h. All 125-volt, 15- and 20-ampere receptacles installed in bathrooms of commercial, industrial, and all nondwelling occupancies
i. All 125-volt, 15- and 20-ampere receptacles installed on roofs
j. Lighting fixtures and lighting outlets installed in the area extending between 5 feet and 10 feet horizontally from the inside walls of a pool, unless installed 5 feet above maximum water level and rigidly attached to structure adjacent to or enclosing the pool
k. All 125-volt, 30 ampere receptacles used for temporary wiring
l. Agricultural buildings in an equipotential plane area
m. Some 125 volt, 15 and 20 ampere receptacles for carnival and similar events
n. Large self-contained tubs and pools

Objective 9

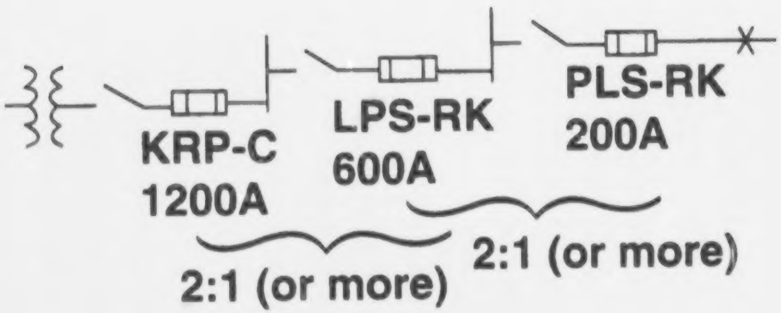
a. All 125-volt, 15- and 20-ampere receptacles in dwelling unit bedrooms

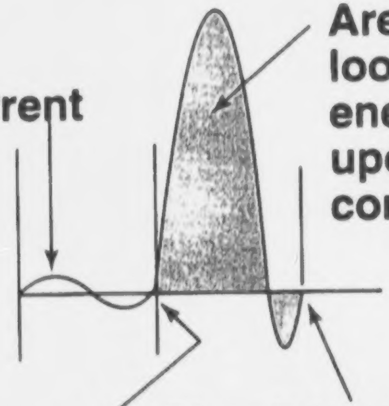
Teacher Supplement 1—Design Plan for Overcurrent Protection Display


3/4" Plywood
Terminals Insulated from Metal Plate
Metal Plate
Ungrounded Conductor
20 Amp Single Pole Switch
Duplex Receptacle
Grounded Conductor
Grounding Conductor

- Place various sizes of wire between terminals starting with 12 Awg and working down.
- Loads can be added to the receptacle.

Selective Coordination


KRP-C
1200A
LPS-RK
600A
PLS-RK
200A
2:1 (or more)
2:1 (or more)

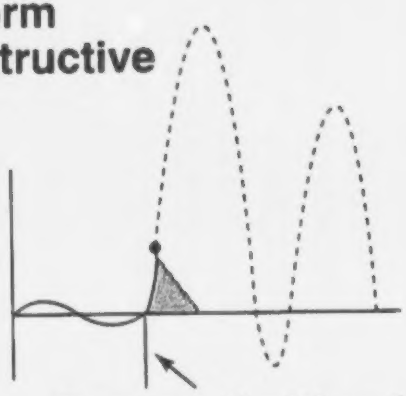


Normal
Load Current

Areas within waveform loops represent destructive energy impressed upon circuit components.

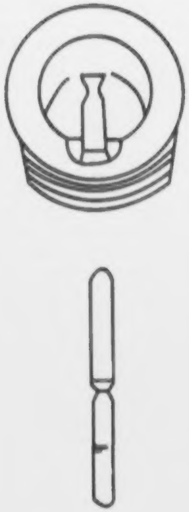
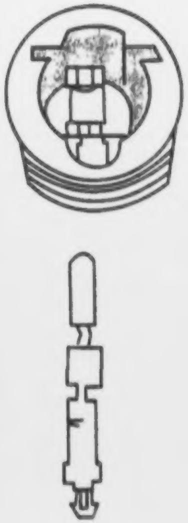
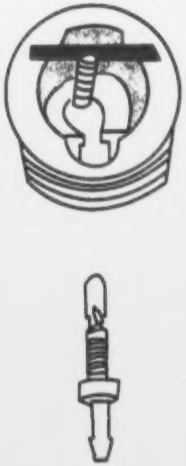
Initiation of
Short-Circuit
Current

Circuit breaker trips and opens short-circuit in about 1 cycle.



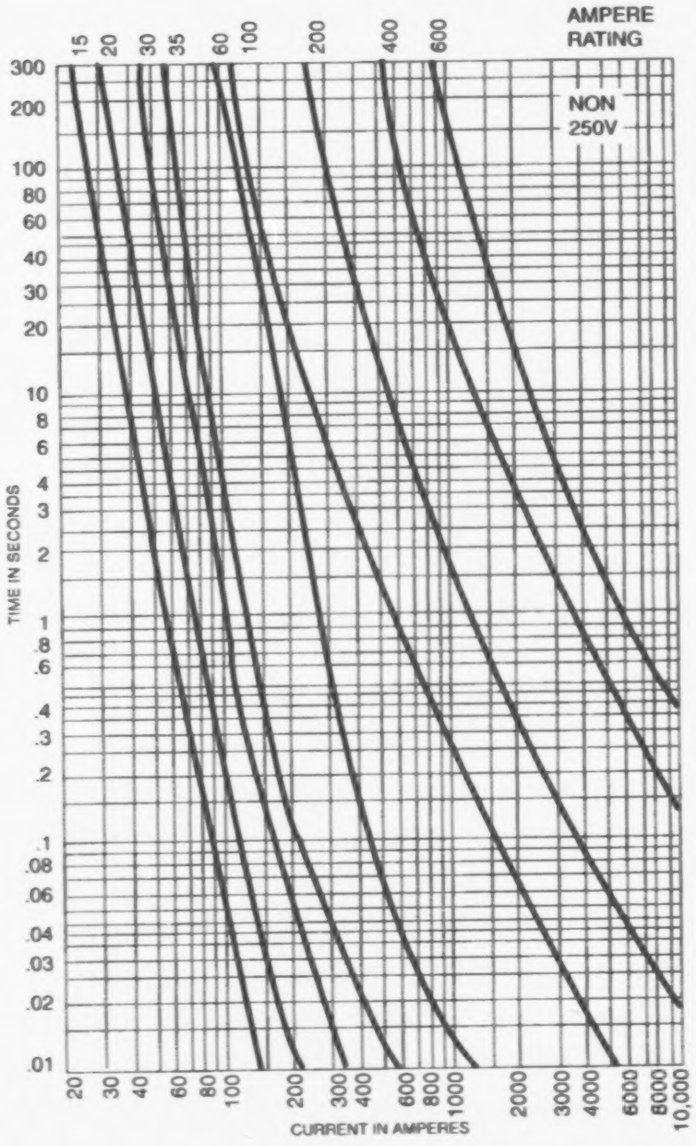
Current-limiting fuse opens and clears short-circuit in less than $1/2$ cycle.

Fuse Elements

Fuse Elements			
Description	**Non-Type-Delay Element is a simple fusible, metal link.** **For general purpose circuit protection.** **Quickly opens (blows) when short-circuit or overload occurs. Use for lighting and other non-motor circuits.**	**Time Delay, Loaded Link** **Heat absorbing metal bead on element link for time delay.** **Passes motor overload starting currents without needlessly opening.**	**Time-Delay, Dual-Element** **For all-purpose application. Like two fuses in one. A simple link element for short-circuits and dangerous overloads plus a series-connected element which lets the harmless overload starting currents of motors pass without opening. Uses less energy, operates cooler, provides superior protection.**

Reprinted with permission of Bussman Division, McGraw-Edison Company

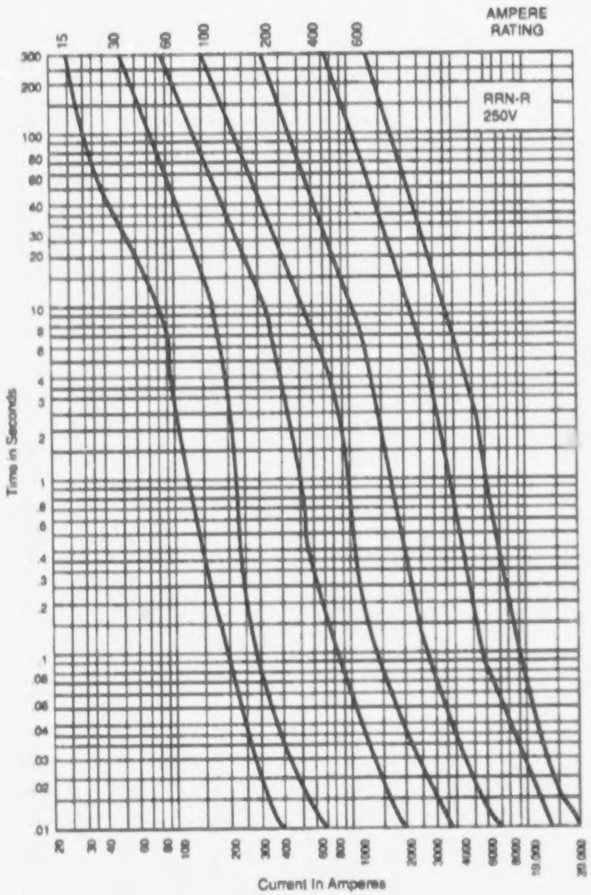
Time-Current Curve Average Melt for One-Time General Purpose NON (Single-Element Fuse)

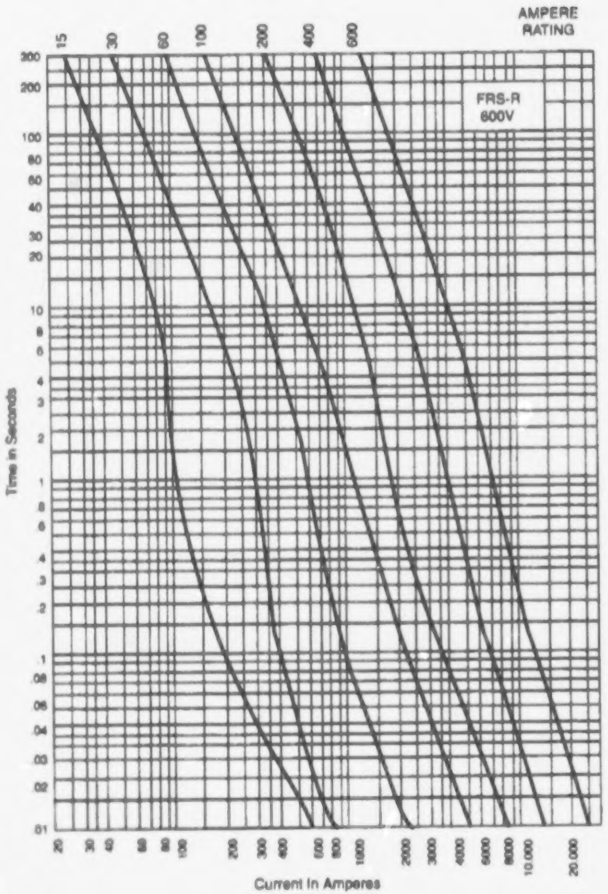


Reprinted with permission of Bussman Division, McGraw-Edison Company

TM 3

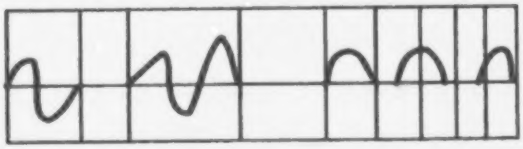
Time-Current Curve Average Melt for Dual-Element Time-Delay FRN-R & FRS-R



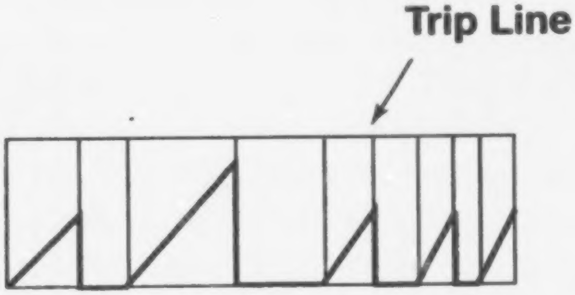


Reprinted with permission of Bussmann Division, McGraw-Edison Company.

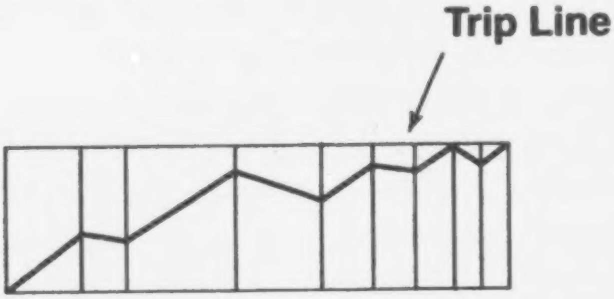
Ground Fault Relaying



Intermittent Ground Fault



Ground Fault Relay Without Memory — Resets After Each Arc



Ground Fault Relay with Memory Cirucit — Does Not Reset So Quickly and Trips to Save Expensive Power Equipment

Used with permission of General Electrical Company

Unit 16 Load Centers and Safety Switches

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 16–3

Answers to Assignment Sheets 16–7

Written Test 16–9

Answers to Written Test 16–15

Transparency Masters

- 1—Parts of a Fusible Single-Phase Load Center Suitable for Service Equipment 16–17
- 2—Parts of a Breaker Load Center 16–19

Student Components

Student Page

Learning Activities Sheet 16–3

Objective Sheet 16–5

Information Sheet 16–7

* Focus Assignment

- Determine Cost of Load Center Construction 159

* Assignment Sheet

- 1—Using the *NEC*, Answer Questions Related to Load Centers . . 161

* Job Sheets

- 1—Install a Safety Switch 163
- 2—Wire a Load Center or Breaker Panel 165
- 3—Wire a Receptacle Circuit to a Load Center 169

* Focus Assignment, Assignment Sheet and Job Sheets are located in Student Workbook 2.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Parts of a Fusible Single-Phase Load Center Suitable for Service Equipment (Objective 6)

  TM 2—Parts of a Breaker Load Center (Objective 7)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Tour the school and residential construction sites to view various load center and safety switch installations.
- Show the class examples of load centers and safety switches, pointing out the purposes of their structural differences.
- Stress the importance of branch circuit overcurrent protection and relate to unit on conductors.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *Digest.* Palatine, IL: Square D Company, 1987.
- Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993.* Quincy, MA: National Fire Protection Association, 1992.
- *Industrial Control Catalog, 1986-87.* Milwaukee, WI: Cutler Hammer Products, 1986.
- *National Electrical Code, 2002.* Quincy, MA: National Fire Protection Association, 2001.
- *National Electrical Code 1999.* Quincy, MA: National Fire Protection Association, 1998.
- Taylor Mark. *Residential Wiring.* Stillwater, OK: Mid-America Vocational Curriculum Consortium 1983.

Suggested Supplemental Resources

Print Media

- Catalog—*Quick Selector Catalog.* Cutler-Hammer Power Distribution Products. Contact at 1-800-958-7050 or www.ch.cutler-hammer.com
- Catalog—*Digest.* Square D Company. Contact at 1-847-397-2600 or www.squared.com
- Catalog—*Hunzicker Brothers, Inc.* Contact at www.hunzicker.com

Answers to Assignment Sheet

Assignment Sheet 1

Using the *NEC*, Answer Questions Related to Load Center

a. No; not a room, but a space as described in 110-26(F), (1) and (2)

b. 240, 250, 312, 314, 404, 500 through 517; Ref. 408.2

c. 10%; Ref. 408.14(B)

d. 42; Ref. 408.15

e. No; Ref. 408.17, 312.2(A)

f. 80; Ref. 210.23(A)(1)

g. Yes; Ref. 408.18

h. 3 feet; Ref. 408.8(B), 110.26(A)(1)

Written Test

Name ____

Date ______________________________ Score ____________

Objective 1

Match the terms related to load center and safety switches with their definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Cabinet
2. Concentric knockout
3. Dead front
4. Disconnecting means
5. Dustproof
6. Dust-tight
7. Eccentrick knockout
8. NEMA (National Electrical Manufacturer's Association)
9. NEMA Type 1
10. NEMA Type 2
11. NEMA Type 3
12. NEMA Type 4
13. NEMA Type 5
14. NEMA Type 12

_____ a. Organization responsible for setting specifications for various classes of enclosures

_____ b. General purpose enclosure for use indoors under usual service conditions

_____ c. Driptight enclosure used indoors to exclude falling moisture and dirt

_____ d. Weather resistant (weatherproof) enclosure suitable for indoor or outdoor use; will exclude falling dirt, light liquid splashing, rain, snow, sleet, and windblown dust

_____ e. Watertight and dustproof enclosure suitable for areas where a great amount of splashing occurs, such as hose down areas

_____ f. Dust-tight enclosure not suitable for use around water

_____ g. Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

_____ h. Enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung

_____ i. A device or group of devices, or other means, by which the conductors of a circuit can be disconnected from their source of supply

Written Test

_____ j. So constructed or protected that dust will not interfere with its successful operation

_____ k. So constructed that dust will not enter the enclosing case

_____ l. So constructed, protected, or treated as to prevent rain from interfering with successful operation of the apparatus

_____ m. So constructed or protected that exposure to a beating rain will not result in the entrance of water

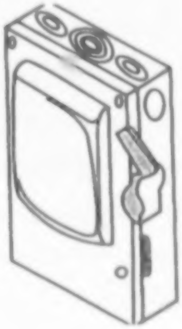
_____ n. Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment

_____ o. Several removable metal rings that allow for the entrance of various standard sizes of connectors into a cabinet

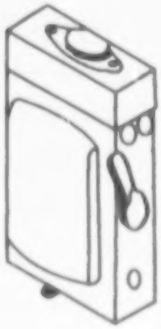
_____ p. Knockout that is removed in sections to form larger holes

Objective 2

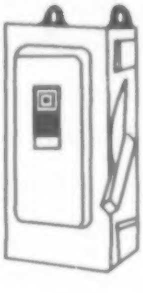
Identify the following types of safety switch enclosures. Write your answers in the blanks provided.



a. ______________________



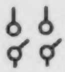
b. ______________________



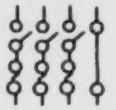
c. ______________________

Objective 3

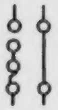
Identify the safety switch system configurations below. Write your answers in the blanks provided.



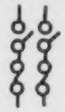
a. ____________



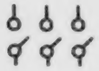
b. ____________



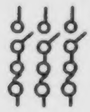
c. ____________



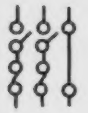
d. ____________



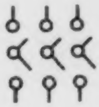
e. ____________



f. ____________



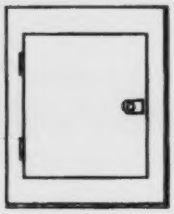
g. ____________



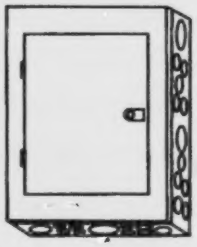
h. ____________

Objective 4

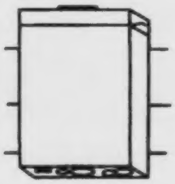
Identify the types of load centers and enclosures below. Write your answers in the blanks provided.



a. ____________



b. ____________

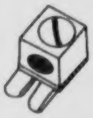


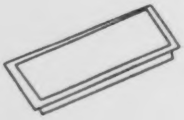
c. ____________

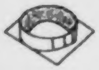
Written Test

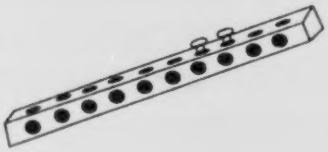
Objective 5

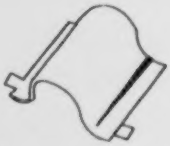
Match common load center accessories with their uses. Write the correct numbers in the blanks.

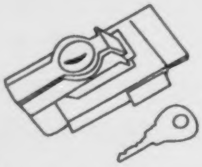

1.

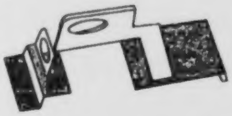

2.

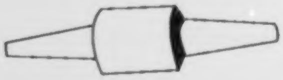

3.


4.


5.


6.


7.


8.

_____ a. Used for termination of conductors

_____ b. Used for termination of circuit grounded conductors

_____ c. Used for termination of equipment grounding conductors

_____ d. Used for locking of cabinet doors to allow entrance of qualified personnel only

_____ e. Used to lock breakers in the "off" or "on" position

_____ f. Used to fill empty breaker spaces where "breakouts" have been removed

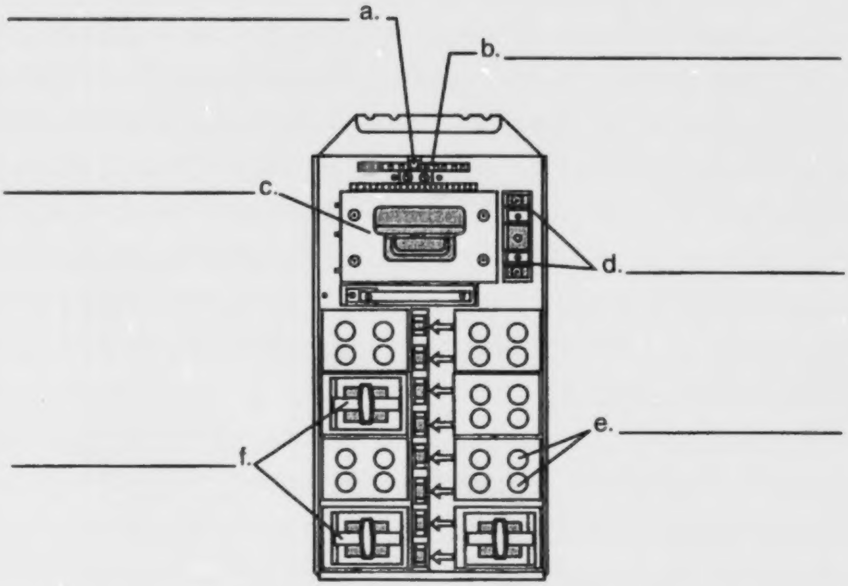
_____ g. Used to lock beakers in the "off" position for equipment maintenance of servicing

_____ h. Used to mechanically tie two or more breaker handles together to assure common tripping

_____ i. Used to allow entrance of conduits to rainproof enclosures

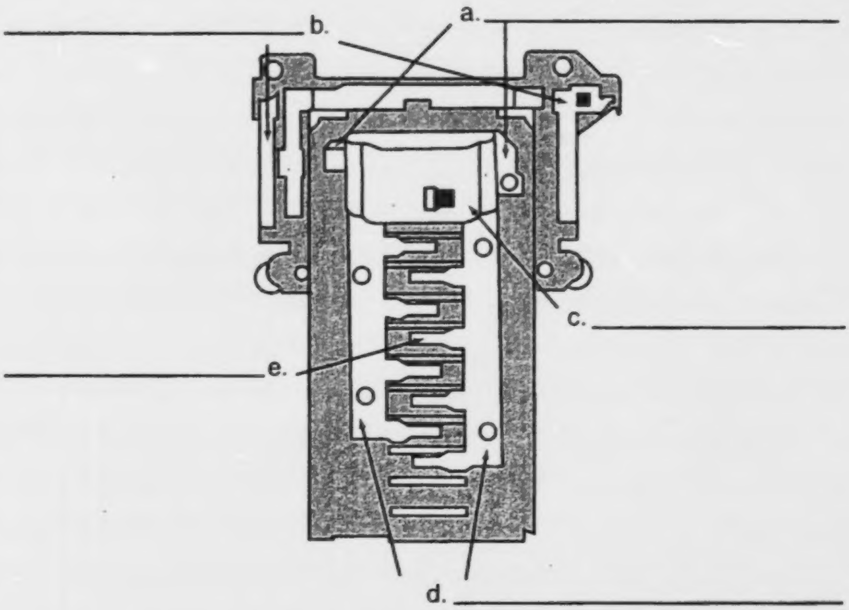
Objective 6

Label the parts of the fusible, single-phase load center illustrated below. Write your answers in the blanks provided.



Objective 7

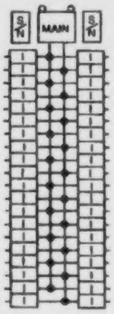
Label the parts of the breaker load center illustrated below. Write your answers in the blanks provided.



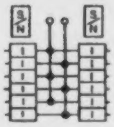
Written Test

Objective 8

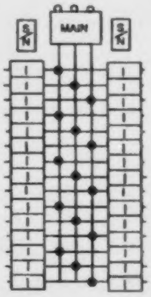
Identify the common panel interior configurations shown below. Write the correct names in the blanks.



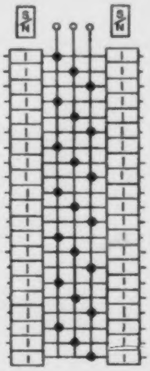
a. ______________________



b. ______________________



c. ______________________



d. ______________________

Objective 9

Select true statements about safety rules for working near load centers and safety switches by placing an "X" in the blanks next to the true statements.

_____ a. Do not tamper with or alter equipment.

_____ b. Install for intended purpose.

_____ c. Install according to *NEC.*

_____ d. Do not hold extra tools in your hand during installation or maintenance.

_____ e. Stand in front of a disconnect before energizing it.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 8
b. 9
c. 10
d. 11
e. 12
f. 13
g. 14
h. 1
i. 4
j. 5
k. 6
l. 15
m. 16
n. 3
o. 2
p. 7

Objective 2

a. NEMA 1 (indoor)
b. NEMA 3R (rainproof)
c. NEMA 4X (watertight, corrosion resistant)

Objective 3

a. 2-pole nonfusible, 2 blades
b. 4-wire S/N 3 blades, 3 fuses
c. 2-wire S/N 1 blade, 1 fuse
d. 2-wire 2 blades, 2 fuses
e. 3-pole nonfusible
f. 3-pole fusible (S/N)
g. 3-wire S/N 2 blades, 2 fuses
h. Three-pole, double-throw

Objective 4

a. Flush mount (NEMA 1)
b. Surface mount (generally NEMA 1)
c. Exterior surface (NEMA 3R)

Objective 5

a. 1
b. 4
c. 4
d. 6
e. 7
f. 2
g. 5
h. 8
i. 3

Objective 6

a. Grounded (neutral) bar
b. Grounding bar
c. Main fuse pullout
d. Line lugs
e. Plug fuse sockets
f. Pull outs

Objective 7

a. Main breaker line lugs
b. Grounded (neutral) bar
c. Main breaker
d. Bus bars
e. Pole spaces

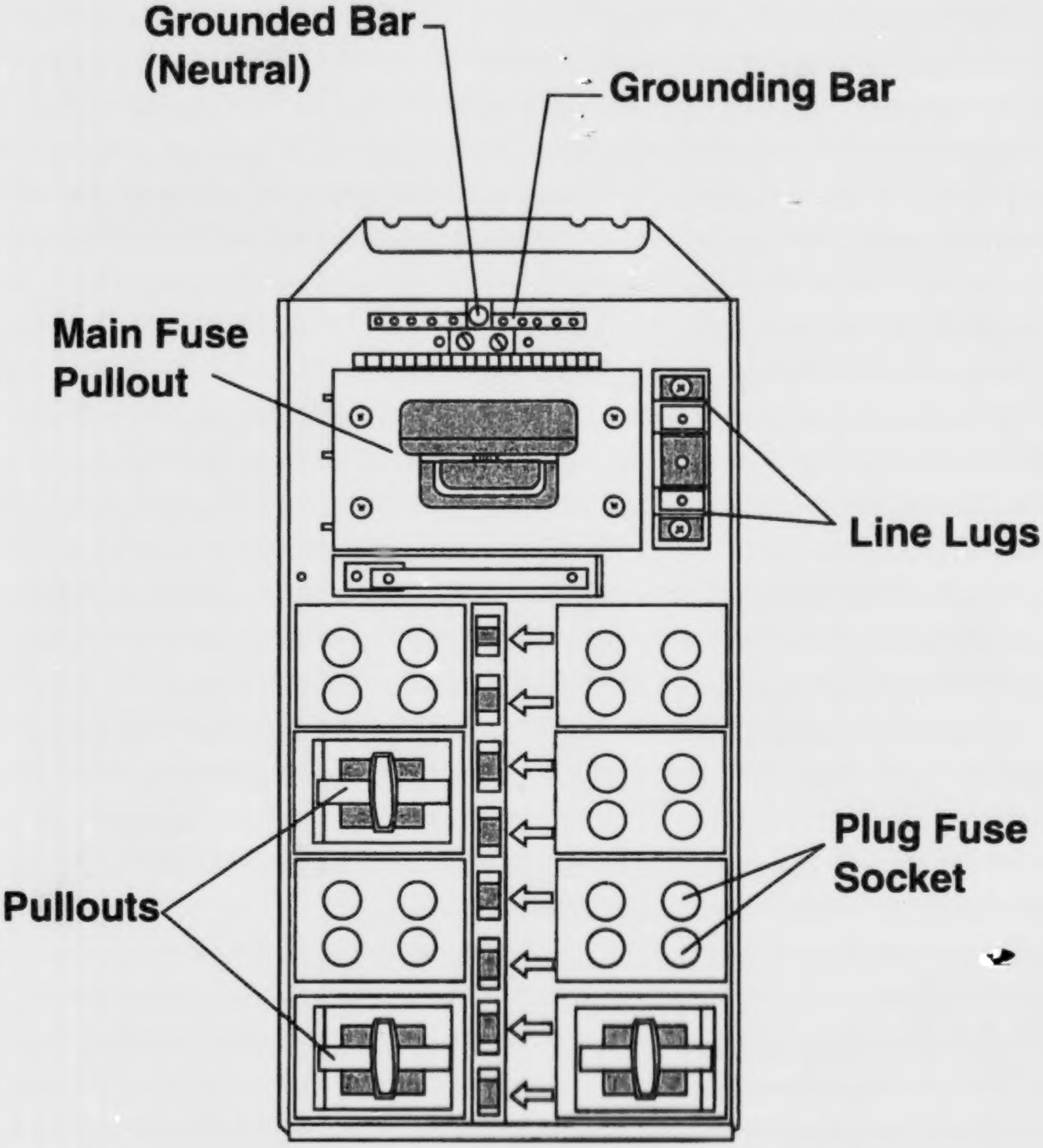
Objective 7

a. Main breaker single phase
b. Main lug only (MLO) single phase
c. Main breaker three phase
d. Main lug only (MLO) three phase

Objective 8

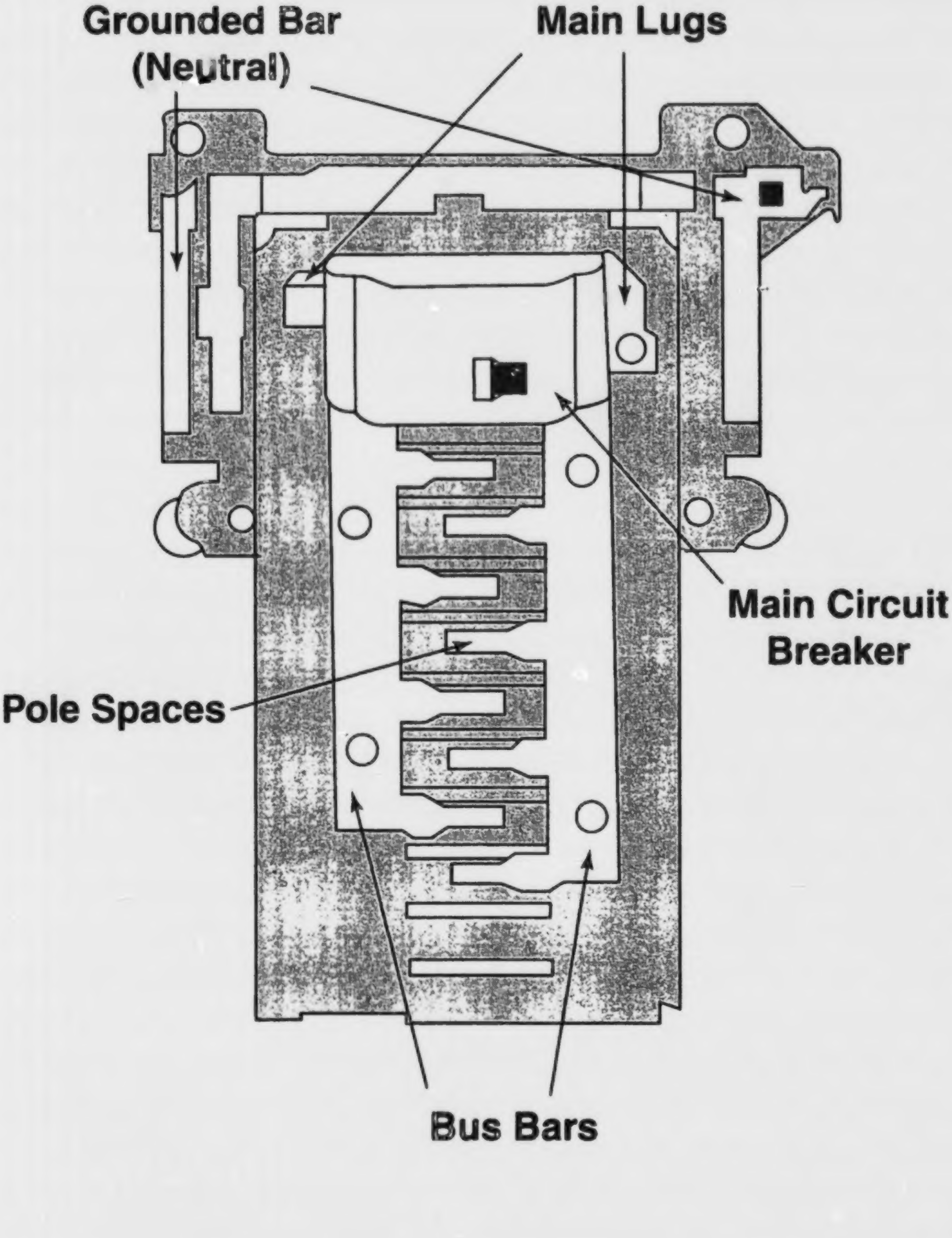
a, b, c, d

Parts of a Fusible Single-Phase Load Center Suitable for Service Equipment


Grounded Bar
(Neutral)
Grounding Bar
Main Fuse
Pullout
Line Lugs
Plug Fuse
Socket
Pullouts

TM 1

Parts of a Breaker Load Center


Grounded Bar (Neutral)
Main Lugs
Main Circuit Breaker
Pole Spaces
Bus Bars

TM 2

Unit 17

Existing Structures

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 17–3

Answers to Assignment Sheets 17–9

Written Test 17–11

Answers to Written Test 17–17

Transparency Masters

1—Construction Members 17–19
2—Construction Members (continued) 17–21
3—Common Routes for New Cable Installations 17–23
4—Common Routes for New Cable Installations (continued) 17–25
5—Working Past Fire Stops 17–27
6—Working Past Fire Stops (continued) 17–29

Student Components

Student Page

Learning Activities Sheet 17–3

Objective Sheet 17–7

Information Sheet 17–9

* Assignment Sheet

1—Determine the Number of Conductors Allowed to
Be Added to an Existing Conduit 173

* Job Sheets

1—Install a metallic box with dry-wall grips in a plasterboard wall 175
2—Secure a box with dry-wall supports (box tins) 179
3—Install a plastic box with dry-wall grips
in a plasterboard wall 183
4—Install a box in a paneled wall 187
5—Install a box in a concrete block wall 191
6—Install a box in a brick wall 195
7—Install a box in a ceiling with an accessible attic 201
8—Install cable between an existing box and a newly installed box
horizontally along a wall in a channel behind bare board 205
9—Install cable between an existing box and a newly installed box,
using an underfloor crawl space 209
10—Install cable between an existing box and a newly installed box,
using attic space 213

* Assignment Sheet and Job Sheets are located in Student Workbook 2.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM1—Construction Members
  TM2—Construction Members (continued)
  TM3—Common Routes for New Cable Installations
  TM4—Common Routes for New Cable Installations (continued)
  TM5—Working Past Fire Stops
  TM6—Working Past Fire Stops (continued)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.

Suggested Activities

- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Explain fishing techniques in two-store houses.
- Take a field trip to a remodeled or old house with exposed construction members.
- Visit a local electrical remodel job on a commercial building.
- Have a local inspector visit the class and discuss remodel work.
- Discuss possible problems that can arise in cutting boxes in existing walls.
- Demonstrate knife scoring techniques for cutting a box opening in plasterboard. Allow students to return your demonstration.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Earley, Mark W., John M. Caloggero, and Richard H. Murray. *National Electrical Code 1993*. Quincy, MA: National Fire Protection Association, 1992.
- Taylor Mark. *Residential Wiring*. Stillwater, OK: Mid-America Vocational Curriculum Consortium 1983.
- *National Electrical Code, 2002*. Quincy, MA: National Fire Protection Association, 2001.
- *National Electrical Code 1999*. Quincy, MA: National Fire Protection Association, 1998.

Suggested Activities

Suggested Supplemental Resources

Print Media

- *2002 NEC Analysis of Changes.* Quincy, MA: National Fire Protection Association, 2001.

  Provides a detailed view of the most important changes in the 2002 NEC

- *NEC 2002 Handbook.* Quincy, MA: National Fire Protection Association, 2001.

  Contains complete Code text plus commentary, photos, and full-color graphics

  The publication(s) listed above can be ordered from:

  National Fire Protection Association
  1 Batterymarch Park
  Quincy, MA 02269-9101
  1-800-344-3555
  www.nfpa.org

- Early, Mark W., et al. *Illustrated Changes in the National Electrical Code.* Delmar Publishers, Inc. 2002.

  Provides a detailed view of the most important changes in the 2002 NEC

- Loyd, Richard. *Electrician's Technical Reference: Wiring Methods.* Delmar Publishers, Inc. 1999.

- Miller, Chris. *Illustrated Guide to the National Electrical Code,* 2nd ed. Delmar Publishers, Inc. 2002.

  Conveniently groups Code requirements according to type or occupancy, and contains 600 illustrations

- Mullin, Ray. *Electrical Wiring Residential*, 14th ed. Delmar Publishers, Inc. 2002.

- Mullin, Ray. *House Wiring with the National Electrical Code*, 11th ed. Delmar Publishers, Inc. 1999.

  Covers everyting from lighting branch circuits, to small and large appliance branch circuits.

- O'Riley, Ronald. *Electrical Grounding,* 6th ed. Delmar Publishers, Inc. 2002.

- Surbrook, Truman and Jonathan Althouse. *Interpreting the National Electrical Code,* 6th ed. Delmar Publishers, Inc. 2002.

  Offers practical examples to illustrate how articles in the Code are applied

- Titus, Patricia A., et al. *Illustrated Dictionary for Electrical Workers,* 2nd ed. Delmar Publishers, Inc. 2002.

491

Electronic Media

- Electrical Wiring Residential Video Series, 2001 (set of eight)

  Video 1: Introduction to Electrical Installations
  Video 2: Planning for Circuit Installation
  Video 3: Special Circuits
  Video 4: Lighting By the Room
  Video 5: GFCI's
  Video 6: Special Purpose Circuits
  Video 7: Miscellaneous and Custom Installations
  Video 8: Service Entrances

Answers to Assignment Sheet

Assignment Sheet 1

Determine the number of conductors allowed to be added to an existing conduit

a. Yes; 6

b. No; 6

c. .829 sq. in. conduit area
.2223 sq. in. for I/O THW
.0507 sq. in. for #6 THHN

$$\begin{array}{r} .2223 \\ \underline{\times 3} \\ .6669 \text{ sq. in.} \end{array}$$

$$\begin{array}{r} .0507 \\ \underline{\times 3} \\ .1521 \text{ sq. in.} \end{array}$$

$$\begin{array}{r} .6669 \\ \underline{+.1521} \\ .8190 \text{ sq. in.} \end{array}$$

.8190 is less than .829 therefore, the additional wires are allowed

d. .275 sq. in. conduit area
.0139 sq. in. for #14 THHW
.0726 sq. in. for #6 TW

$$\begin{array}{r} .0139 \\ \underline{\times 3} \\ .0417 \text{ sq. in.} \end{array}$$

$$\begin{array}{r} .0726 \\ \underline{\times 4} \\ .2904 \text{ sq. in.} \end{array}$$

$$\begin{array}{r} .0417 \\ \underline{+.2904} \\ .3321 \text{ sq. in.} \end{array}$$

.3321 is greater than .275; therefore, a new conduit must be run.

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match the terms related to existing structures with their correct definitions. Write the correct numbers in the blanks.

1. Brick bat
2. Channel
3. Cross sectional area
4. Drop chain
5. Drop cloth
6. Fish
7. Fish wire
8. Lath and plaster
9. Pipe chase
10. Plasterboard (Sheetrock®)
11. Stud finder
12. Underfloor crawl space

_____ a. Groove formed in materials

_____ b. Establishing a connection between two points so that a cable can be installed

_____ c. Length of wire with a hook formed in one end to catch materials being fished in a space

_____ d. Working space underneath the house

_____ e. Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

_____ f. Flat sheet used in construction as a wall covering; it has an outer covering of felt sandwiching a gypsum plaster core

_____ g. Cloth used to catch falling debris from cutting or chipping work

_____ h. Compass-type tool that uses a magnet to find nails and thus indicate stud locations

_____ i. Piece of brick

_____ j. Area in square inches allowed in a conduit or tubing; area for conductors in a conduit or tubing

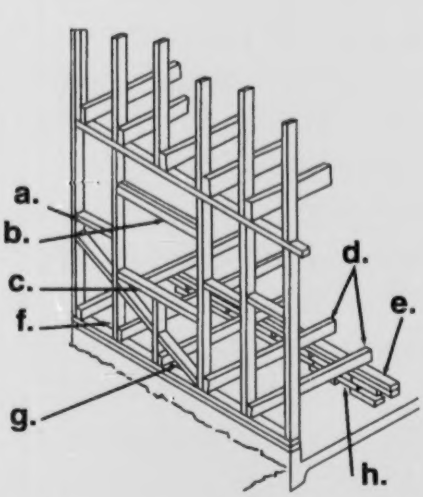
_____ k. Short length of small chain used to pull conductors or flexible conduit through an enclosed space or wall cavity

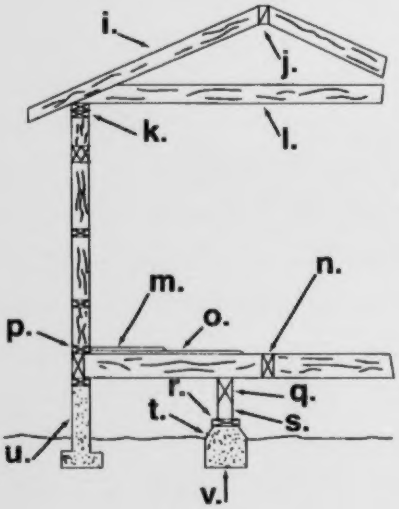
_____ l. Usually, a vertical space between two floors, dedicated for the running of pipes and conduits between floors

Written Test

Objective 2

Identify the construction members common in existing structures shown in the two illustrations below. Write the correct names in the blanks.




i.
j.
k.
l.
m.
n.
o.
p.
q.
r.
s.
t.
u.
v.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

l. ______________________________

m. ______________________________

n. ______________________________

o. ______________________________

p. ______________________________

q. ______________________________

r. ______________________________

s. ______________________________

t. ______________________________

u. ______________________________

v. ______________________________

Objective 3

List four common routes for new cable installations in existing structures.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 4

Complete the following list of possible methods for getting cable through or around construction members. Write in the blanks the word(s) that best completes the list.

a. Top plates

(1) ______________ drilling

(2) ______________ drilling

(3) Lifting a ______________ and drilling

(4) Over ______________ ______________ and back through insulation board inside eave

b. Bottom plates (sole plate)

(1) ______________ drilling behind baseboard

(2) ______________ drilling

c. Fire stops

(1) Lifting shingle and ______________ drilling through block with extension

(2) Top drilling with door trim and baseboard ______________

(3) Top drilling and ______________ past

Written Test

Objective 5

List five wall or ceiling compositions that may be found in an existing structure.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 6

Complete the following statements about conditions for using optional calculations for additional loads to existing installations. W[illegible] in the blanks the word(s) that best completes each statement.

a. The maximum demand data is available in KVA for a minimum of a ______________ period.

b. Th[illegible]xisting demand at 125 percent plus the new load does not exceed the ampacity of the feeders or ______________ of the service.

c. The feeder or service has ______________ in accordance with sections 23.90 and 240.3 of the *NEC*.

Objective 7

Arrange in order the steps for determining the number of conductors allowed in a conduit, based on conductors of the same size and type. Write a "1" before the first step, a "2" before the second step, and so on.

_____ a. Determine number of size of existing conductors.

_____ b. Find the conductor type and size listed under that type of conduit.

_____ c. Determine size of existing conduit.

_____ d. Determine number of conductors that may be added.

_____ e. Find the type of conduit in Appendix C, Tables C1-C12(A).

Objective 8

Arrange in order the steps for determining the number of conductors allowed in a conduit, based on conductors of different sizes or types. Write a "1" before the first step, a "2" before the second step, and so on.

_____ a. Compute total area occupied by existing conductors, based on Table 5, Chapter 9 of the *NEC*.

_____ b. Determine size of existing conduit.

_____ c. Determine number of conductors that may be added.

_____ d. Find area of conduit or tubing, using Table 4, Chapter 9 of the *NEC*.

_____ e. Determine number and size of existing conductors.

Objective 9

Select true statements concerning replacement of receptacles in existing structures by placing an "X" in the blank next to each true statement.

_____ a. Gronding-type receptacles must be used and connected to the grounding conductor if a means of grounding exists in the receptacle enclosure or a grounding conductor is properly installed.

_____ b. If required by *Code* at the replacement location, ground-fault circuit-interrupter receptacles shall replace all other types of receptacles.

_____ c. Nongrounding-type receptacles 'shall only be replaced with nongrounding-type receptacles.

_____ d. A ground-fault circuit-interrupter may replace a nongrounding-type receptacle if marked with the words "No Equipment Ground".

_____ e. A grounding-type receptacle may be replaced with a nongrounding type receptacle where supplied through a ground-fault circuit-interrupter if marked with the words "GFCI Protected" and "No Equipment Ground".

Objective 10

List permitted connections for equipment grounding conductors when replacing nongrounding-type receptacles with grounding-type receptacles and for branch-circuit extensions only in existing structures that do not have equipment-grounding conductors in the branch circuit.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. For grounded systems, ______________________________

____

e. For ungrounded systems, ______________________________

____

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 2
b. 6
c. 7
d. 12
e. 8
f. 10
g. 5
h. 11
i. 1
j. 3
k. 4
l. 9

Objective 2

a. Fire stop
b. Header
c. Sill
d. First floor joists
e. Plate
f. Stud
g. Brace
h. Sleeper wall
i. Rafter
j. Ridge board
k. Top plate
l. Ceiling joists
m. Flooring
n. Bridging
o. Subfloor
p. Bottom plate (sole plate)
q. Girder
r. Pier block
s. Girder post
t. Pier
u. Foundation wall
v. Footing

Objective 3

a. Vertically in a wall
b. Horizontally in a channel behind baseboard
c. Horizontally in underfloor crawl space
d. Horizontally in an attic

Objective 4

a. (1) Straight
    (2) Angle
    (3) Shingle
    (4) Top plate
b. (1) Top
    (2) Bottom
c. (1) Top
    (2) Removal
    (3) Channeling

Answers to Written Test

Objective 5

a. Plasterboard
b. Lath and plaster
c. Paneling
d. Concrete block
e. Brick

Objective 6

a. 1 year
b. Rating
c. Overcurrent protection

Objective 7

a. 2
b. 4
c. 1
d. 5
e. 3

Objective 8

a. 4
b. 1
c. 5
d. 3
e. 2

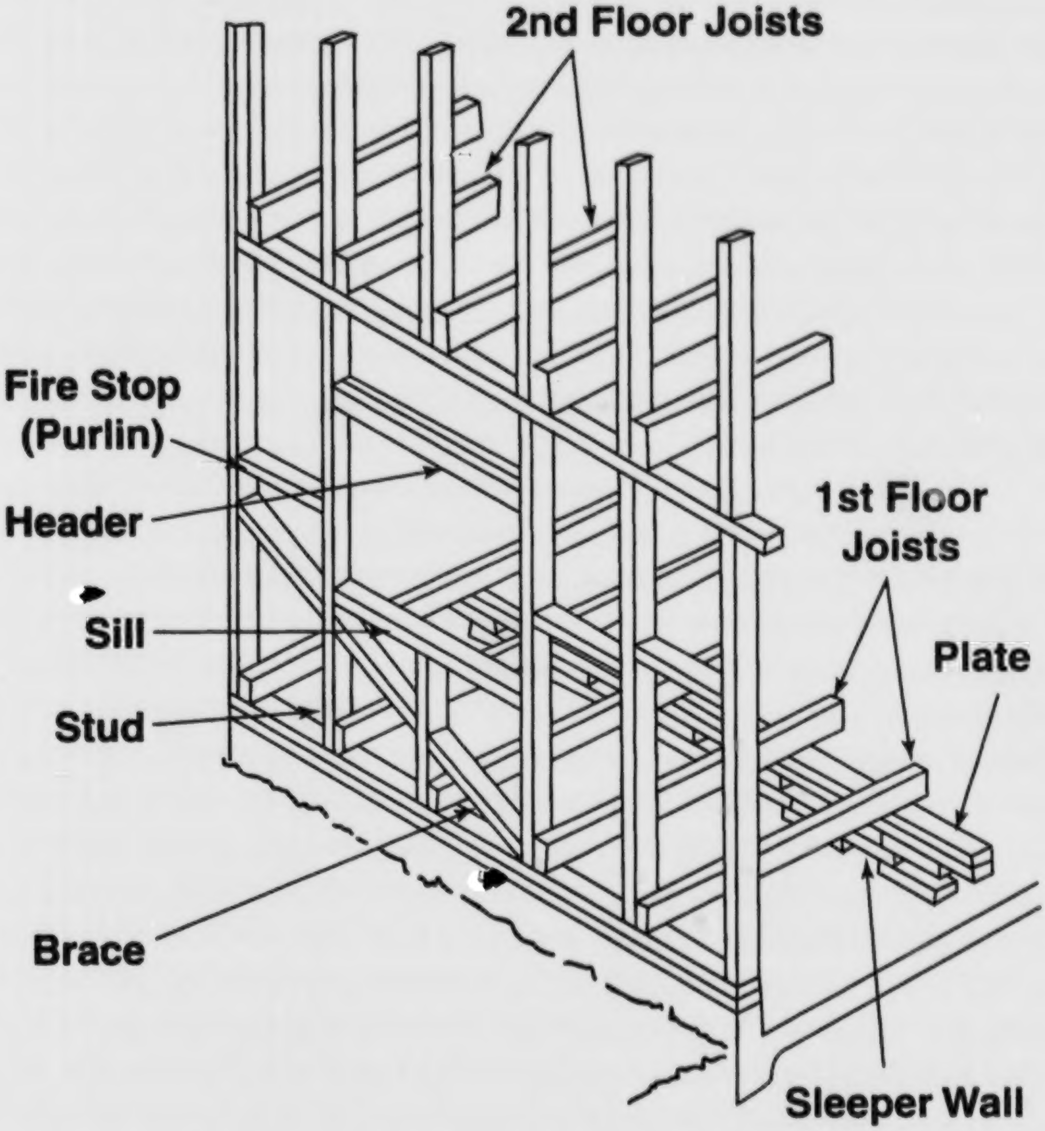
Objective 9

a, d

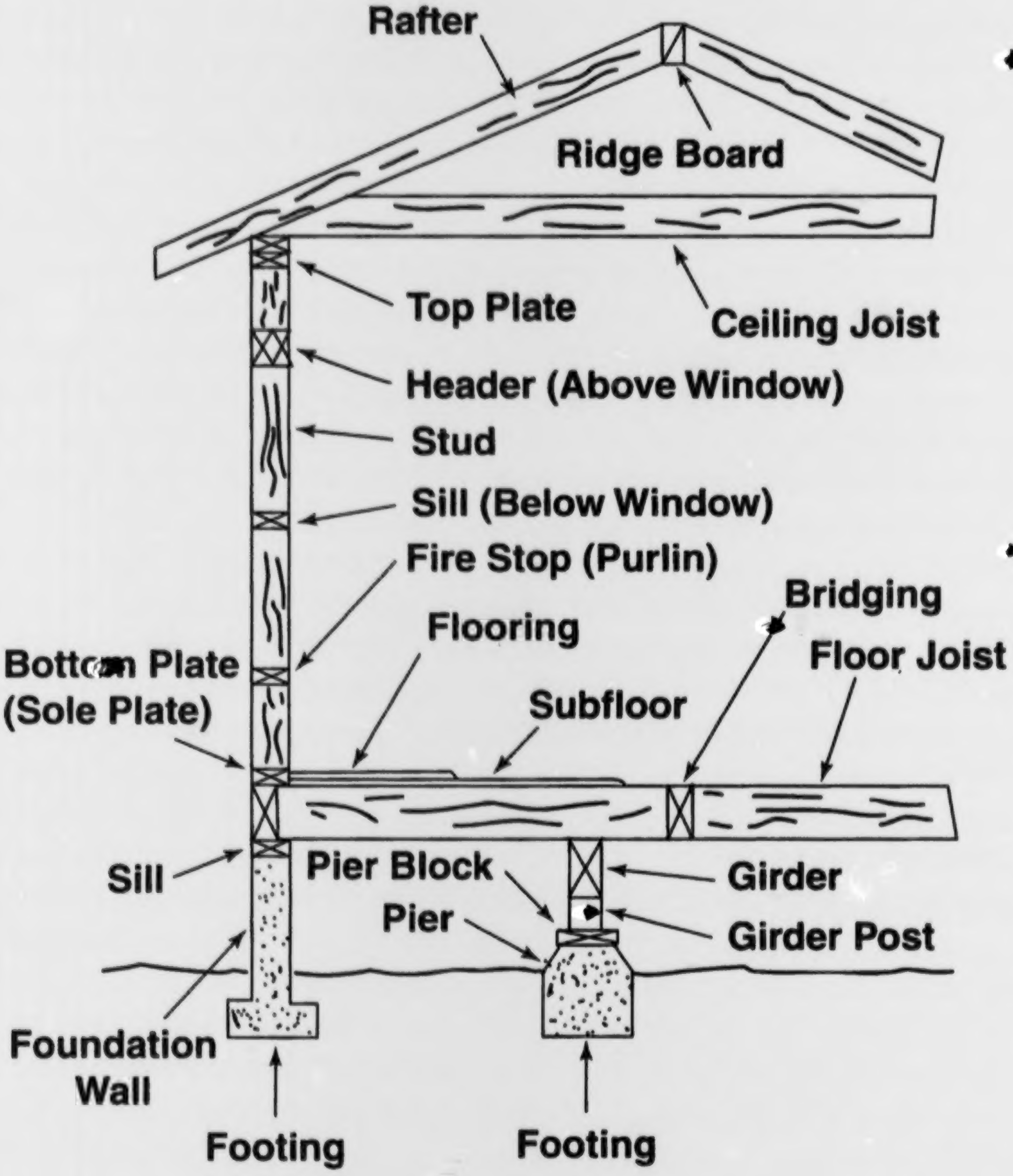
Objective 10

a. Any accessible point on the grounding electode system.
b. Any accessible point on the grounding electrode conductor.
c. The equipment grounding terminal bar within the enclosure where the branch circuit for the receptacle or branch circuit originates.
d. For grounded systems, the grounded service conductor within the service equipment enclosure.
e. For ungrounded systems, the grounding terminal bar within the service equipment enclosure.

Construction Members

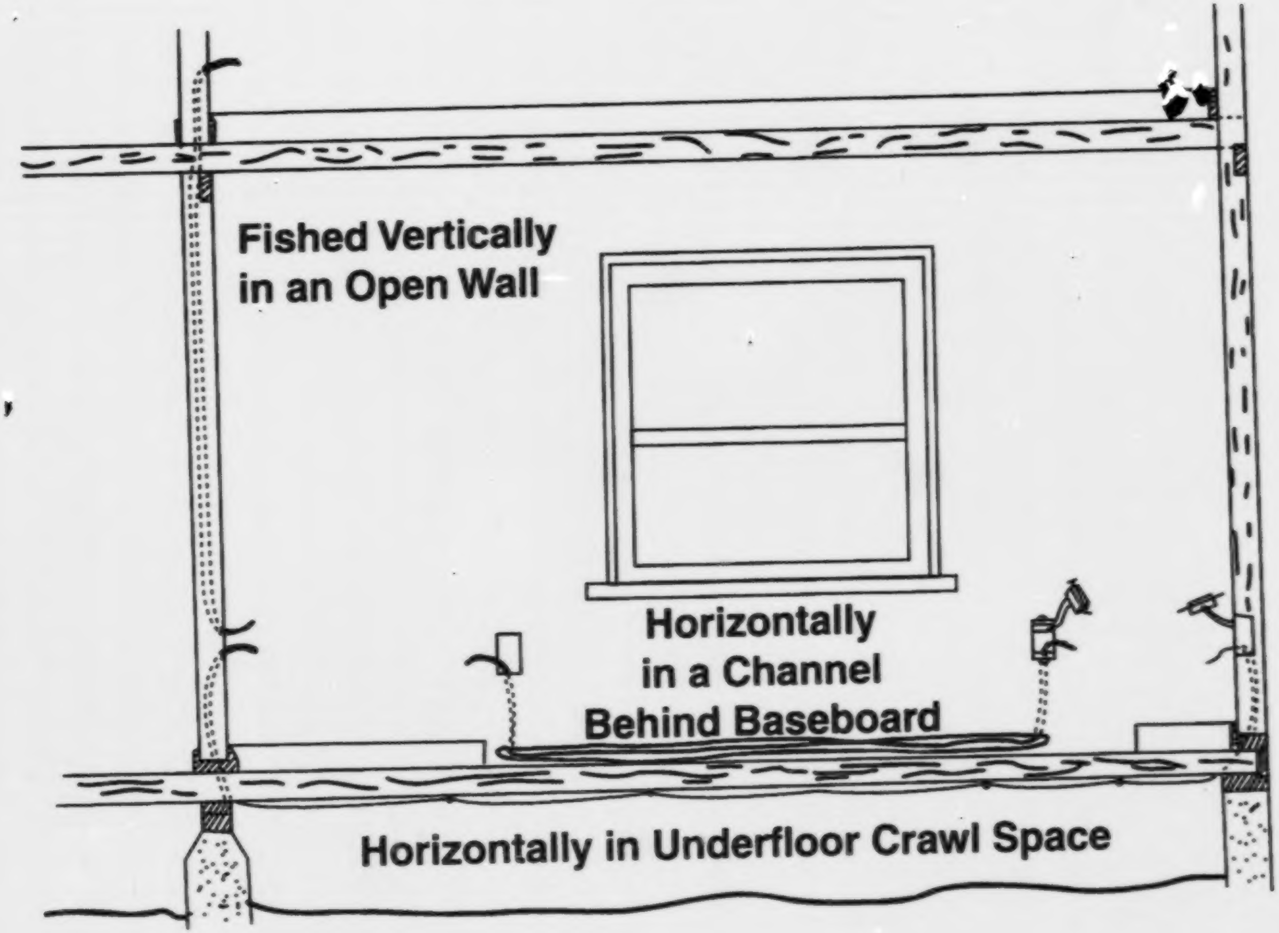

2nd Floor Joists
Fire Stop (Purlin)
Header
1st Floor Joists
Sill
Plate
Stud
Brace
Sleeper Wall

Construction Members (continued)

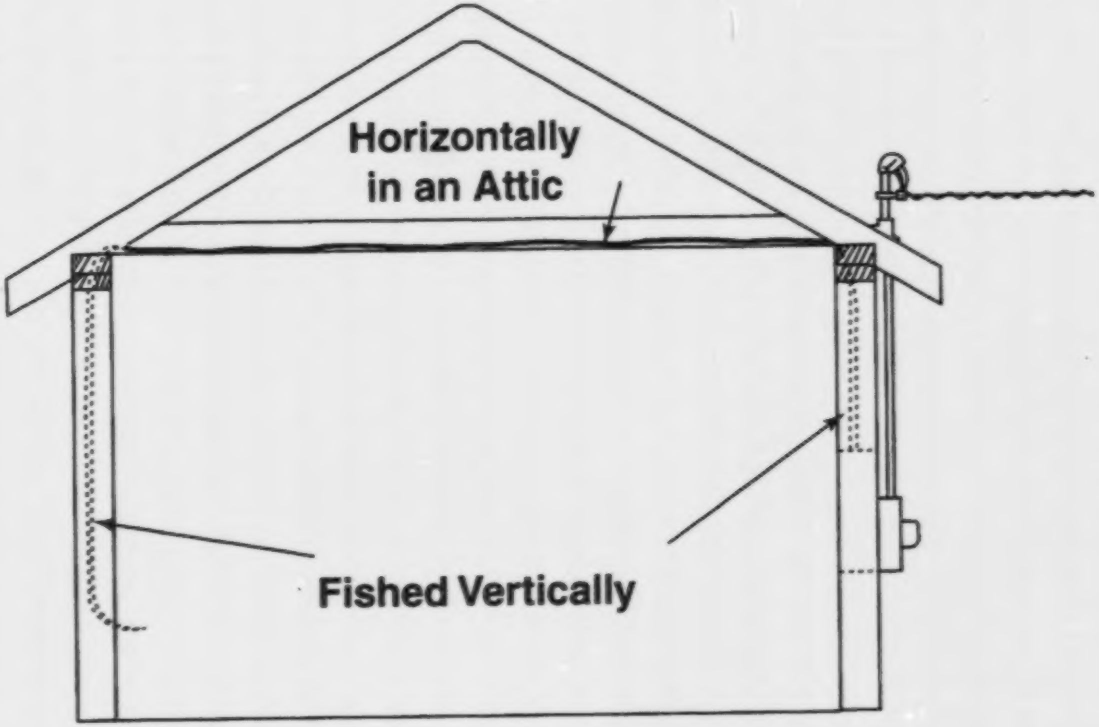

Rafter
Ridge Board
Top Plate
Ceiling Joist
Header (Above Window)
Stud
Sill (Below Window)
Fire Stop (Purlin)
Bridging
Flooring
Floor Joist
Bottom Plate
(Sole Plate)
Subfloor
Sill
Pier Block
Girder
Pier
Girder Post
Foundation
Wall
Footing
Footing

TM 2

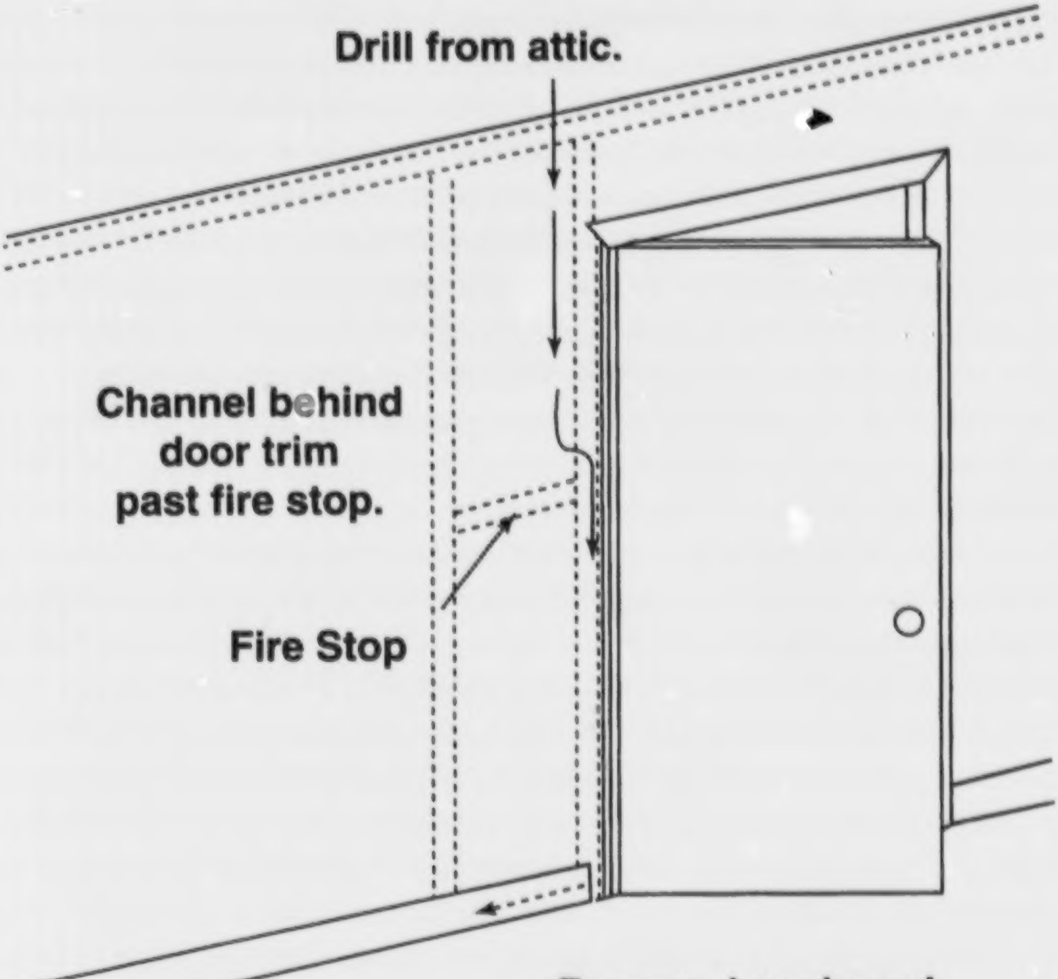
Common Routes for New Cable Installations


Fished Vertically
in an Open Wall
Horizontally
in a Channel
Behind Baseboard
Horizontally in Underfloor Crawl Space

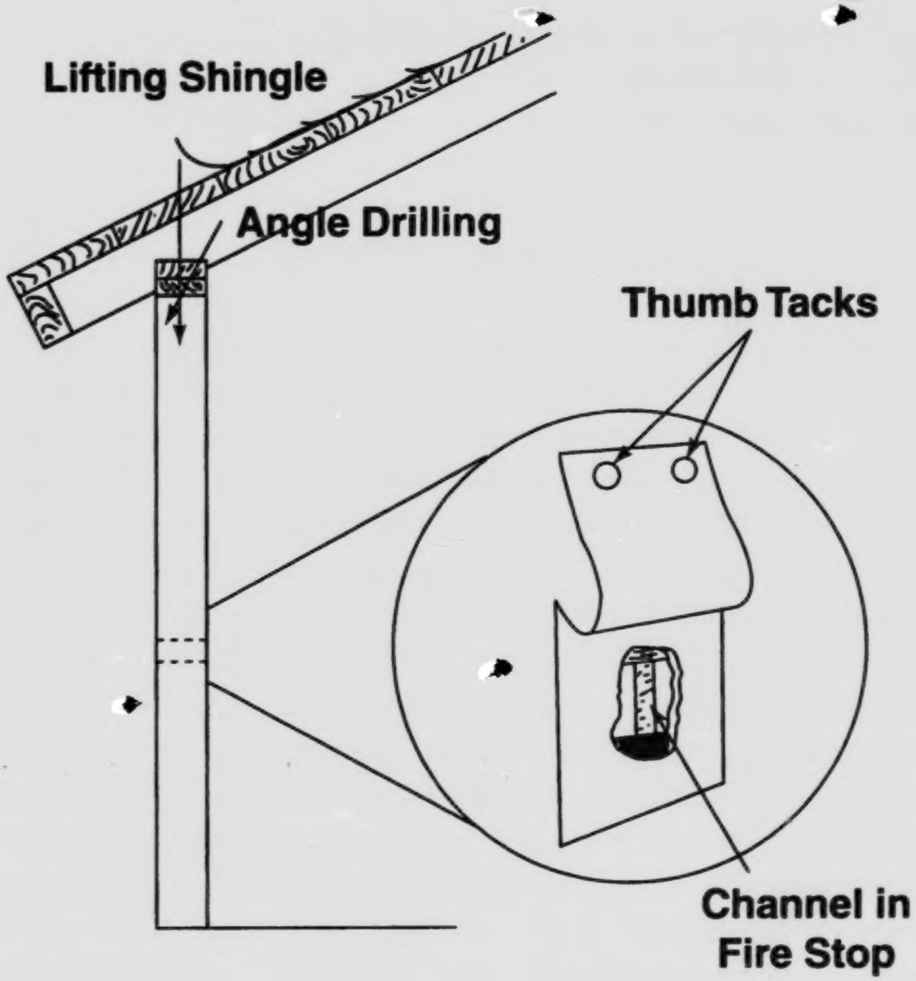
Common Routes for New Cable Installations (continued)


Horizontally in an Attic
Fished Vertically

Working Past Fire Stops


Drill from attic.
Channel behind door trim past fire stop.
Fire Stop
Remove baseboard channel to new outlet.

Working Past Fire Stops (continued)


Lifting Shingle
Angle Drilling
Thumb Tacks
Channel in
Fire Stop

BASIC WIRING

Fourth Edition

Stude u e

4
5
6
MADE IN U.S.A.
WEAR SAFETY GOGGLES*7A
12-16
10-14
12-10
4-40
6-32
8-32

MAVCC

References 2002
National Electrical Code

2-015641 CN801302

507

Basic Wiring

Fourth Edition

Student Guide

Written by

Stan Kaltwasser
Gary Flowers
Don Blasingame

Revised by

Dan Ipock
Glenn Fleming

Project coordinated by

Glenn Fleming

Developed by

Multistate Academic and Vocational Curriculum Consortium, Inc.
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

©2002

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

02-015641 801302

©2002 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Printed in the United States of America by the
Oklahoma Department of Vocational-Technical Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Table of Contents

Units of Instruction

Unit 1: Occupational Introduction

Unit 2: General Safety and First Aid

Unit 3: Electrical Safety

Unit 4: Related Math and Measuring

Unit 5: Hand Tools

Unit 6: Powered/Specialty Tools and Equipment

Unit 7: Using Trade Information

Unit 8: Basic Equipment

Unit 9: Basic Theory

Unit 10: DC Circuits

Unit 11: AC Circuits

Unit 12: Wiring Methods

Unit 13: Conductors

Unit 14: Low Voltage Wiring

Unit 15: Overcurrent Protection

Unit 16: Load Centers and Safety Switches

Unit 17: Existing Structures

Unit Contents

Student Components

Student Page

Learning Activities Sheet 1–3

Objective Sheet 1–5

Information Sheet 1–7

* Focus Assignment

List Careers Associated with the Electrical Trade 1

* Assignment Sheets

1—Interview an Electrical Worker 3

2—Compare Employment Opportunities in the Electrical Field 5

* Focus Assignment and Assignment Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment.

☐ 4. **Stop** Ask instructor to evaluate the completed focus assignment. After work has been evaluated, follow instructor's recommendations.

☐ 5. **Study** Information Sheet, Objectives 1 thru 6.

☐ 6. **Do** Assignment Sheet 1, "Interview an Electrical Worker."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 and 6.

☐ 8. **Study** Information Sheet, Objectives 7 thru 10.

☐ 9. **Do** Assignment Sheet 2, "Compare Employment Opportunities in the Electrical Field."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 8 and 9.

Optional

☐ 11. **Research** Online resources regarding the electrical career field. Visit www.mikeholt.com as one of your sources.

☐ 12. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 13. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss the occupational outlook of the electrical field. The student should demonstrate these competencies by completing the focus assignment and assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Define *NEC* and *occupation*.
2. State the major purposes of the *NEC*.
3. List areas the *NEC* is intended to cover.
4. List areas the *NEC* is not intended to cover.
5. List job responsibilities of electrical workers.
6. Select from a list desirable physical abilities of electrical workers.
7. List employment opportunities in the electrical field.
8. List occupational hazards related to electrical work.
9. Match electrical trade organizations with their descriptions.
10. Complete statements about *Code* compliance.
11. List careers associated with the electrical trade. (Focus Assignment)
12. Interview an electrical worker. (Assignment Sheet 1)
13. Compare employment opportunities in the electrical field. (Assignment Sheet 2)

Information Sheet

Objective 1

Define *NEC* and Occupation

a. ***National Electrical Code* (*NEC*)**—A publication developed by the National Fire Protection Association to help safeguard persons and property from hazards arising from the use of electricity

Note: The *National Electrical Code* is updated every 3 years.

b. **Occupation**—The vocation or activity at which a person works.

Objective 2

Major purposes of the *NEC*

a. The *NEC* sets the minimum standards for electrical work in general and specific instances.

Note: Any person employed in the electrical field should obtain a copy of the *NEC* and know how to use it. The *NEC* is commonly referred to as "the electrician's bible."

b. The purpose of the *NEC* is the "practical safeguarding of persons and property from hazards arising from the use of electricity."

c. The *NEC* is considered necessary for safety: compliance with the *Code* will result in an installation that is free from hazard; this does not guarantee efficiency or adequacy for future expansion.

d. The *NEC* is not intended to be a design manual or an instructional manual for untrained individuals.

e. The *NEC* protects the consumer from dangerous installations of electrical wiring and serves as a means for testing and protecting those who install said wiring.

f. The *NEC* is considered to be suitable for mandatory enforcement by government bodies having legal jurisdiction.

Objective 3

Areas the *NEC* is intended to cover

a. Installations of electric conductors and equipment in and on public and private buildings

b. Installations of conductors and equipment that connect to the supply of electricity

c. Installations of outside conductors and equipment

d. Installation of fiber optic cable

Objective 4

Areas the *NEC* is not intended to cover

a. Installations in ships, watercraft, railway rolling stock, aircraft, and automotive vehicles

b. Installations underground in mines and self-propelled mobile surface mining equipment and its trailing cables

c. Installation of railways used exclusively for operation of rolling stock or exclusively for signaling and communications

d. Installation of communication equipment under control of communication utilities

e. Installations under the exclusive control of electrical utilities

Objective 5

Job responsibilities of electrical workers

Note: The student entering the electrical field should be aware of the need for continued study. As industry changes, new methods and techniques will become industry standards. Electrical workers are expected to use and interpret the *National Electrical Code*, as well as perform complex mathematical calculations.

a. Install all types of electrical equipment.

b. Hang electrical fixtures.

c. Install switching and power outlets.

d. Install appliances.

e. Design electrical systems.

f. Understand and interpret blueprints.

g. Install and maintain electronic controls for machines.

h. Practice good work ethic; be dependable and honest.

i. Be courteous to customers and co-workers.

j. Communicate effectively with people.

k. Practice good personal hygiene.

l. Participate in trade organizations.

Examples: IBEW, AIECA, AGC, NECA, ABC

Objective 6

Desirable physical abilities of electrical workers

a. Ability to distinguish colors

Note: Many components and conductors commonly used in the electrical field are color coded. It is imperative that workers are able to distinguish colors readily.

b. Ability to lift heavy objects

c. Ability to work in confined areas such as crawl spaces and attics

d. Ability to stand for long periods

e. Ability to work on ladders and scaffolds

f. Ability to work with hands in a skillful manner

Objective 7

Employment opportunities in the electrical field

a. **Electrician's helper**—Person who assists an electrician

b. **Installer**—Person who installs electrical equipment under the supervision of a journeyman

c. **Apprentice**—Helper enrolled in a formal training program

d. **Journeyman**—Electrician working under the supervision of a contractor

e. **Master electrician or contractor**—Person licensed to enter contractual agreements involving electrical work

f. **Maintenance electrician**—Person who maintains and repairs electrical equipment and processes

g. **Electrical parts/equipment salesperson**—Person who works for an electrical wholesale parts outlet

h. **Inspector**—Person who represents the authority having jurisdiction over electrical installations

Objective 8

Occupational hazards related to electrical work

Note: The electrical worker is a highly respected trade worker. The jobs that are performed are generally in areas or surroundings more desirable than those in other trades. However, demanding conditions do occur. Inclement weather is also a factor.

a. **Death**—Careless and unsafe work habits can result in fatal accidents

b. **Burns**—Accidental shorts or faults occasionally blow slag or molten metal, which can burn

c. **Broken bones or bruises**—Working on ladders or in other hazardous construction situations can result in falls

d. **Sprains or muscle tear**—Many pieces of electrical equipment are heavy and bulky; often help must be summoned to avoid injury to the worker

Information Sheet

Objective 9

Electrical trade organizations

Note: There are many trade organizations available to those employed in the electrical industry. These organizations serve a vital function to the electrician and electrical contractor. They serve to provide updates on the latest equipment and methods as well as new Code changes. These organizations play a vital role in effecting legislation that affects the industry. As a student it is important to participate in your local student vocational organization. This experience will provide you with an insight into the workings of a trade organization. Internet addresses are provided where applicable.

a. **IEC** (Independent Electrical Contractors)—An organization of electrical contractors that employ nonunion personnel (www.ieci.org)

b. **IBEW** (International Brotherhood of Electrical Workers)—A trade union of workers engaged in electrical installations and maintenance; provides training and placement for its members (www.ibew.org)

c. **AIECA** (American Independent Electrical Contractors Association)—An organization of independent electrical contractors or "merit shop" contractors; provides training for the employees of its members

d. **AGC** (Associated General Contractors)—An organization of general contractors in the construction industry; provides training to employees of its members in all construction trade areas (www.agc.org)

e. **NECA** (National Electrical Contractors Association)—An organization of electrical contractors that employ primarily IBEW electricians and apprentices (www.necanet.org)

f. **ABC** (Associated Builders and Contractors)—A national trade organization devoted to the merit shop philosophy which aims to provide the best management techniques, the finest craftsmanship, and the most competitive bidding and pricing strategies in the industry (www.abc.org)

g. **IAEI** (International Association of Electrical Inspectors)—A leading proponent for electrical safety, they bring together inspectors, electricians, contractors, manufacturers, and testing labs to promote safe use of electrical systems and products. An excellent internet site for an explanation of the *NEC* (www.iaei.com)

Objective 10

Code compliance

a. The electrical contractor and journeyman electrician are obligated to comply with local, state, and national codes.

b. Failure to comply could result in the loss of property and lives.

c. Failure to comply can result in the revocation of license or permits.

d. Failure to comply can result in the loss of livelihood.

Unit 2 General Safety and First Aid

Unit Contents

Student Components

Student Page

Learning Activities Sheet 2-3

Objective Sheet 2-7

Information Sheet 2-9

Student Supplements

1—Complete a Student Safety Pledge Form 2-43
2—Guidelines for Interpreting Material Safety Data Sheet 2-45
3—Using Portable Fire Extinguishers 2-51
4—A Systematic Look At First Aid 2-53

* Focus Assignment

Locate Material Safety Data Sheets 7

* Assignment Sheets

1—Interpret a Material Safety Data Sheet 9
2—Draw a Layout of Your School Shop and Apply the Safety Color *Code* 15
3—State Portable Fire Extinguisher Types, Symbols, and Operating Instructions 17
4—Identify and Correct Safety Violations 19

* Job Sheets

1—Operate a Fire Extinguisher 21
2—Lift a Heavy Object Properly 23
3—Place and Climb a Ladder Safely 25

* Focus Assignment, Assignment Sheets, and Job Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

📖 ☐ 2. **Read** Objective Sheet.

Optional 📖 ☐ 3. **Read** "OSHA Safety and Health Standards."

☐ 4. **Do** Focus Assignment.

☐ 5. **Stop** Ask instructor to evaluate the completed focus assignment. After work has been evaluated, follow instructor's recommendations.

☐ 6. **Study** Information Sheet, Objectives 1 thru 5.

Optional 📼 ☐ 7. **View** Videotapes entitled: "General Safe Work Practices", and "Hazard Communications–Right-To-Know."

☐ 8. **Study** Information Sheet, Objectives 6 and 7.

Optional 📼 ☐ 9. **View** Videotape entitled: "Fall Protection."

☐ 10. **Study** Information Sheet, Objectives 8 through 10.

Optional 📼 ☐ 11. **View** Videotapes entitled: "Confined Space Entry", and "Respirators and How to Use Them."

☐ 12. **Do** Student Supplement 1, "Complete the Student Safety Pledge Form", and return to instructor.

☐ 13. **Study** Information Sheet, Objectives 11 through 15, and Student Supplement 2, "Guidelines for Interpreting a Material Safety Data Sheets."

Optional 📖 ☐ 14. **Read** "Material Safety Data Sheet: Handbook For the Preparation of MSDSs Worldwide"

Learning Activities Sheet

☐ 15. **Do** Assignment Sheet 1, "Interpret a Material Safety Data Sheet."

☐ 16. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat steps 13 and 15.

☐ 17. **Study** Information Sheet, Objectives 16 and 17.

☐ 18. **Do** Assignment Sheet 2, "Draw a Layout of Your School Shop and Apply the Safety Color Code."

☐ 19. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, repeat steps 17 and 18.

☐ 20. **Study** Information Sheet, Objectives 18 through 21, and Student Supplement 3, "Using Portable Fire Extinguishers."

Optional ☐ 21. **Read** "Fire Extinguishers, Rating and Fire Test, Ul 711."

Optional ☐ 22. **View** Videotape entitled: "Fire Extinguisher Training."

☐ 23. **Do** Assignment Sheet 3, "State Portable Fire Extinguisher Types, Symbols, and Operating Instructions."

☐ 24. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 25. If the evaluation is not satisfactory, repeat steps 20 and 23.

☐ 25. **Do** Job Sheet 1, "Operate a Fire Extinguisher."

☐ 26. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 27. If the evaluation is not satisfactory, repeat step 25.

☐ 27. **Study** Information Sheet, Objectives 22 through 24.

Optional ☐ 28. **View** Videotapes entitled: "Lifting Safely in Construction", "Slips and Falls in Construction", and "Preventing Back Injury Through Exercise."

☐ 29. **Do** Job Sheet 2, "Lift a Heavy Object Properly."

☐ 30. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 31. If the evaluation is not satisfactory, repeat steps 27 and 29.

Optional ☐ 31. **View** Videotape entitled: "Book-em Danno."

☐ 32. **Do** Assignment Sheet 4, "Identify and Correct Safety Violations."

☐ 33. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 34. If the evaluation is not satisfactory, review objectives 1 through 24 and repeat step 32.

☐ 34. **Study** Information Sheet, Objectives 25 through 27.

Optional ☐ 35. **View** One or both videotapes entitled: "Ladder Safety in Construction", and "Scaffold Safety."

☐ 36. **Do** Job Sheet 3, "Place and Climb a Ladder Safely."

☐ 37. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 38. If the evaluation is not satisfactory, repeat steps 34 and 36.

☐ 38. **Study** Information Sheet, Objectives 28 through 30, and Student Supplement 4, "A Systematic Look at First Aid."

Optional ☐ 39. **Read** One or both books entitled: "American Red Cross: Adult CPR", and "American Red Cross: First Aid and Safety."

Optional ☐ 40. **View** Videotapes entitled: "Bloodborne Pathogens", "Heat Stress", and "Killer Bees, Wasps, and Spiders."

☐ 41. **Check** With instructor for any additional assignments to be completed.

☐ 42. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 43. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify hazardous job conditions, practice good work and shop safety, and perform basic first aid. The student should demonstrate these competencies by completing the focus assignment, assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to general safety with their definitions.
2. Complete guidelines for dressing safely on the job.
3. Select true general job and shop safety rules.
4. List shop conditions that should be reported.
5. Select words to complete statements about OSHA's role in workplace health and safety.
6. Match terms related to fall protection systems to their definitions.
7. Select true statements about fall protection systems.
8. Match terms related to confined space entry to their characteristics.
9. List employer/employee responsibilities associated with confined space entry.
10. List environmental contaminants that require use of a respirator.
11. Select true statements about hazardous cleaners and lubricants.
12. Select words to complete statements about the storage of hazardous materials.
13. Distinguish between two common hazardous materials found at the job site.
14. Select words to complete the purposes of material safety data sheets (MSDS).
15. Describe ways hazardous materials can enter the body.
16. Match colors of the safety color code with their uses.
17. Match safety tags with their color coding.
18. List the components of the fire triangle.

19. Match types of fires with their classifications.
20. Match general types of fire extinguishers with their uses.
21. Complete fire extinguisher general operating instructions that follow the letters P-A-S-S.
22. Match causes of back injuries with their contributing factors.
23. Select words to complete guidelines for lifting and moving items safely.
24. List guidelines for preventing slips, trips, and falls.
25. Select words to complete rules for using ladders safely.
26. Select from a list safety guidelines for using scaffolds.
27. Select from a list safety guidelines for using power lifts.
28. List in order the general steps for handling any emergency situation.
29. Complete general guidelines for first-aid emergencies.
30. Describe basic first-aid procedures for various emergency situations.
31. Locate Material Safety Data Sheets (Focus Assignment)
32. Interpret a material safety data sheet. (Assignment Sheet 1)
33. Draw a layout of your school shop and apply the safety color code. (Assignment Sheet 2)
34. Interpret portable fire extinguisher symbols. (Assignment Sheet 3)
35. Identify and correct safety violations. (Assignment Sheet 4)
36. Operate a fire extinguisher. (Job Sheet 1)
37. Lift a heavy object properly. (Job Sheet 2)
38. Place and climb a ladder safely. (Job Sheet 3)

Information Sheet

Objective 1

Terms and definitions

a. **Accident**—Suddenly occurring, unintentional event that causes injury or property damage

b. **Acquired Immune Deficiency Syndrome (AIDS)**—Life-threatening blood-borne virus that depresses the cells of the immune system

Note: It is important to protect yourself against AIDS infection when administering first aid to a victim. See information sheet objective 30.

c. **Anaphylactic shock**—Severe and sometimes fatal reaction to an antigen (as bee venom); characterized by respiratory symptoms, fainting, and itching

d. **Cardiopulmonary resuscitation (CPR)**—Procedure for restoring normal breathing after cardiac arrest

e. **Carelessness**—Failure to think before one acts; failure to pay attention

f. **Combustible**—Capable of bursting into flames at temperatures above 100°F

g. **Electrical shock**—The sudden stimulation of nerves and muscles caused by the discharge of electricity through the body when the body contacts an energized electrical circuit

Note: Electrical shock can cause serious burns, muscle damage, and death. Human body resistance varies from about 500,000 ohms when dry to about 300 ohms when wet. Because of this, voltages as low as 30 volts can cause enough current to be fatal. Any circuit with a potential of at least 30 volts must be considered dangerous.

h. **First aid**—Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

i. **First-degree burn**—Burn affecting only the outer skin layers; characterized by redness and pain

j. **Flammable**—Capable of being easily ignited and burning quickly at temperatures below 100°F

Note: *Inflammable* means "flammable."

k. **Grounded**—Electrical connection to an object that conducts electrical current to the earth

l. **Hazard**—Potential source of danger

m. **Hazardous material**—Any cancer-causing, corrosive, toxic, irritant, sensitizer, or material that has, or has the potential for, damaging effects on specific body organs

Examples: Bleaches, petroleum products, paints, chlorine and other pool chemicals, cleaning and sanitizing agents, varnishes, paint removers, and carbon monoxide from vehicle exhausts

n. **Heel**—To apply pressure to the bottom of a straight or extension ladder to prevent if from slipping or sliding sideways while in use

o. **Hepatitis**—Infectious disease marked by inflammation of the liver

Note: It is important to protect yourself against hepatitis infection when administering first aid to a victim. See Information Sheet Objective 30.

p. **Hygiene**—Conditions or practices of cleanliness conducive to health

q. **Material safety data sheet (MSDS)**—Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

Note: The Federal Hazardous Communications (HazCom) states that all employees must have access to MSDSs and be taught to read and understand them.

r. **Occupational Safety and Health Act (OSHA)**—Federal legislation designed to ensure safe and healthful working conditions for employees

s. **Safety**—Freedom from danger, risk, or injury

t. **Second-degree burn**—Burn penetrating beneath the superficial skin layers; characterized by swelling and blisters

u. **Third-degree Burn**—Burn that destroys all skin layers and underlying tissue; characterized by white, leathery appearance and lack of pain

Note: Third-degree burns are not painful because nerve tissue has been destroyed.

Objective 2

Dressing safely on the job

a. Wear clothing appropriate for the activity being performed.

b. Wear hard hats and safety shoes on all construction sites.

c. Always wear safety glasses when working.

d. Remove ties and dangling jewelry when working with or near machine tools or rotating equipment.

e. Confine long hair before operating rotating equipment.

f. Remove rings and other jewelry when working in the shop.

g. Wear protective clothing as appropriate.

Examples: Suitable helmets and goggles when welding; eye protection when using electric tools such as saws or drills; face mask when working with invasive fumes; seatbelt at all times when in a moving vehicle

h. Wear dust masks in dusty areas.

i. Wear hearing protection when subjected to continuous loud noise.

j. Wear gloves when handling equipment and materials with sharp edges.

Objective 3

General job and shop safety rules

a. **Awareness and safe conduct**

- Be alert for dangers and hazards.
- Conduct yourself in a safe manner; do not participate in horseplay.
- Do not work overtime in the shop unless the instructor is present.
- Consider the safety of others.
- Do not distract workers operating a tool or machine.
- Work with adequate light.

b. **Hygiene and safety from disease**

- Do not come to work or school sick, and do not continue working if you become sick.
- Use soap and water frequently as a method of preventing and transferring disease.

c. **Fire safety**

- Be familiar with the location of building exits, and fire-fighting and first-aid equipment.
- Be aware of the surroundings before plugging in a power tool.

  Example: Are there any explosives or combustible materials in the area?

d. **Tool use, maintenance, and storage safety**

- Use the right tool or equipment for the job, and use it properly.

  Examples: A stepladder instead of furniture; a screwdriver or scraping tool, not the tip of a kitchen knife

- Keep all tools, sharp, clean, and in safe working order.
- Retain all tool guards and safety devices.
- Operate a hazardous machine only after receiving instruction on how to operate the machine safely in all working conditions.
- Make sure that all guards and barriers are in place and adjusted properly before using a machine or tool.
- Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held.
- Keep work areas clean and free of debris and other hazards.
- Store tools, materials, and supplies safely in cabinets, on shelves, or other suitable areas.
- Keep sufficient brooms, brushes, and other housekeeping equipment readily available.
- Clean chips from a machine with a brush, not with a rag or your bare hands.
- Wear eye protection when using grinders and buffers.

e. **Hazardous materials safety**

- Use a solvent only after determining its properties, the kind of work it's intended for, and how to use it.
- Use and store potentially hazardous materials and products strictly according to label instructions and cautions.
- Clean up any spilled liquids immediately.
- Store oily rags or oily waste in self-closing or spring-lid metal containers.

f. **Electrical safety**

- Check all equipment before energizing or activating.
- Disconnect the power from energized tools, and tag or lockout machine tools before performing any maintenance task such as oiling or cleaning.
- Do not run over electrical cords with dollies or carts.
- Do not string electrical cords across traffic lanes.
- Turn off the power before leaving an energized tool or machine.

Objective 4

Shop conditions that should be reported

a. Equipment defects

b. Any condition that can lead to an accident

c. All accidents and injuries, no matter how minor

Objective 5

Facts about OSHA's role in workplace health and safety (www.osha.gov)

a. Became federal law on April 28, 1971

b. Operates under the U.S. Department of Labor

c. Sets two major requirements for employers:

- To furnish each employee a place of employment that is free from recognized hazards that are causing or likely to cause death or serious physical harm to employees
- To comply with the occupational safety and health standards contained within the OSHA regulations

d. Sets one major requirement for employees:

- To comply with occupational safety and health standards and all rules, regulations, and orders pursuant to OSHA regulations that are applicable to the employee's worn actions and conduct

e. Requires employers to keep records of occupational injuries and illness of their employees

Note: Employers must record all occupational fatalities, lost-workday illnesses and injuries, and nonfatal illnesses and injuries without lost workdays but which require medical treatment. Medical treatment does not include first-aid treatment.

f. Requires that employers establish a written, comprehensive hazard communication program that includes provisions for container labeling, material safety data sheets, and an employee training program. The program must include a list of hazardous chemicals in each work area, the means the employer uses to inform employees of the hazards of non-routine tasks (for example, the cleaning of reactor vessels), hazards associated with chemicals in unlabeled pipes, and the way the employer will inform other employers of the hazards to which their employees may be exposed.

g. Often sets only minimum standards and requirements

h. Provides for federal OSHA officers who inspect facilities and levy penalties for noncompliance

Objective 6

Terms associated with fall protection systems

a. **Anchorage**—A secure point of attachment for lifelines or lanyards

b. **Body Belt (safety belt)**—A strap with means both for securing it about the waist and for attaching it to lanyard, lifeline, or deceleration device

c. **Body Harness**—Straps which may be secured about the employee in a manner that will distribute the fall arrest forces over at least the thighs, pelvis, waist, chest and shoulders with means for attaching it to other components of a personal fall arrest system

d. **Connector**—A device which is used to couple (connect) parts of the personal fall arrest system

e. **Guardrail Systems**—A barrier erected to prevent employees from falling to lower levels

f. **Hole**—A gap or void 2 inches or more in dimension, in a floor, roof, or other walking/working surface

g. **Lanyard**—A flexible line of rope or strap which generally has a connector at each end for connecting the body harness to a deceleration device, lifeline, or anchorage

h. **Lifeline**—A component consisting of a flexible line for connection to an anchorage at one end to hang vertically, or at both ends to hang horizontally

i. **Lower Levels**—Those areas or surfaces to which an employee can fall. Such areas or surfaces include, but are not limited to, ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures, or an portion of these

j. **Personal Fall Arrest System**—A system used to arrest an employee in a fall from a working level. It consists of an anchorage, connectors, a body harness, and may include a lanyard, deceleration device, lifeline, or suitable combinations of these.

k. **Safety Net**—A net erected under a walking/working level when guardrail systems or personal fall arrest systems are not feasible

l. **Walking/Working Level**—Any surface, whether horizontal or vertical, on which an employee walks or works, including, but not limited to, floors, roofs, ramps, bridges, scaffolds, and runways, but not including ladders, vehicles, or trailers, on which employees must be located in order to perform their job duties

Objective 7

Fall Protection Systems (governed by OSHA Standard 29 CFR–1925.502)

Note: It's the responsibility of the employer to determine if the walking/working surfaces on which its employees are to work have the strength and structural integrity to support employees safely.

Each employee on a walking/working surface with an unprotected edge which is 6 feet or more above a lower level, shall be protected from falling by the use of guardrail systems, safety net systems or personal fall arrest systems.

a. **Guardrail Systems**

- Used primarily on scaffolding, around holes, and on ramps and runways
- Top edge height of a guardrail shall be 42 inches plus or minus 3 inches above the walking/working level

b. **Safety Net**

- Shall be installed as close as practical under the walking/working surface on which employees are working, but in no case more than 30 feet below that level
- Shall be inspected at least once a week for wear, damage, and other deterioration
- Materials, scrap pieces, equipment, and tools which have fallen into the safety net shall be removed as soon as possible from the net and at least before the next work shift

c. **Personal Fall Arrest System**

Caution: Effective January 1, 1998, body belts are not acceptable as part of a personal fall arrest system.

- Attachment point of the body harness shall be located in the center of the wearer's back near shoulder level, or above the wearer's head
- Shall be inspected prior to each use for wear, damage and other deterioration, and defective components shall be removed from service
- Shall not be attached to guardrail systems nor hoists
- Anchorages used for attachment of personal fall arrest equipment shall be independent of any anchorage being used to support or suspend platforms and capable of supporting at least 5,000 lbs. per employee attached.
- Shall be rigged so that an employee can neither free fall more than 6 feet nor contact any lower level

Note: The employer shall provide for prompt rescue of employees in the event of a fall or shall assure that employees are able to rescue themselves.

Objective 8

Terms associated with confined space entry (governed by OSHA Standard 29 CFR–1910.146)

a. **Confined Space**—Any space that has the following characteristics:

- Large enough or so configured that an employee can bodily enter and perform assigned work
- Has limited or restricted means for entry or exit. Confined-space openings are limited primarily by size and location. Openings may be small in size and may be difficult to move through easily. Entrance and exit may be required from top, bottom, or side. Size or location may make rescue efforts difficult
- Is not designed for continuous employee occupancy

b. **Non-Permit Confined Space**—A confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

c. **Permit-Required Confined Space**—A confined space that has one or more of the following characteristics:

- Contains or has potential to contain a hazardous (toxic or oxygen deficient) atmosphere
- Contains a material that has the potential for engulfing an entrant (flammable atmosphere)
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section (mechanical or physical hazard)
- Contains any other recognized serious safety or health hazard

d. **Permit-Required Confined Space Program**—The employer's overall program for controlling, and where appropriate, for protecting employees from, permit space hazards and for regulating employee entry into permit spaces.

Objective 9

Employer/employee responsibilities concerning confined space entry

a. Employer responsibilities

- Determine whether confined spaces require a permit to enter.
- If the workplace contains permit spaces, the employer shall inform exposed employees, by posting danger signs or by any other equally effective means, of the existence and location of, and the danger posed by the permit spaces.

  Note: A sign reading "DANGER–PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER" or using other similar language would satisfy the requirement for a sign.

- If your employer decides that its employees will enter permit spaces, the employer shall develop and implement a written permit space program.
- Provide all equipment necessary to allow the employee to complete the job safely
- Provide training so that all employees who may enter confined spaces acquire the understanding, knowledge, and skills necessary for the safe performance of duties.

b. Employee responsibilities

- Never enter any confined space without first finding out whether it requires a permit.
- If entry does require a permit, thoroughly read all instructions before entering and ensure the permit is posted at the entry portal so you can confirm that pre-entry preparations have been completed.
- Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure.
- Never enter a permit-required confined space without an attendant present, and always maintain constant communication with the attendant.
- Alert the attendant whenever you detect a prohibited condition.
- Properly use provided equipment.

Objective 10

Respirator requirements

a. Respirators shall be used anytime the work environment is contaminated with:

- Harmful dusts
- Fogs
- Fumes
- Mists
- Gases
- Smokes
- Sprays
- Vapors

Objective 11

Hazardous cleaners and lubricants

Note: Many cleaners and lubricants contain petroleum, acids, and/or alkaline bases that may be hazardous to your health. Read and follow label instructions for proper use and storage.

Cleaner	Type	Application
Alcohol, ethyl	Petroleum solvent	Cleaning solder connections Thinning shellac and rosin
Acetone	Petroleum solvent	Removing oily films, paints, and lacquer Cementing lucite
Bright dip	Acid mixture containing sulfuric, hydrochloric and nitric acids	Cleaning metal surfaces after etching or soldering
Butyl cellulose	Petroleum solvent	Thinning and washing epoxy resin inks
Cyclohexanone	Petroleum solvent	Thinning vinyl solvents and cements
Hydrochloric acid	Diluted acid	Removing mill scale from steel (bright dip ingredient)
Isophorone	Petroleum solvent	Washing up vinyl inks
Isophorone alcohol	Petroleum solvent	Removing oil, grease, and flux from conductors and terminals, both before and after soldering
Kerosene	Petroleum solvent	Cutting machine fluid
Ketone, methyl ethyl	Petroleum solvent	Thinning lacquer and removing paint
Lacquer thinner	Petroleum solvent	Thinning and washing up lacquer and lacquer ink
Mineral spirits	Petroleum solvent	Washing up and thinning rubber, oil, ethyl cellulose inks, and alkyd enamels
Perchlorethylene	Chlorinated solvent	General-purpose cleaning and vapor degreasing
Phosphoric acid	Diluted acid	Removing milk scale from steel

Sodium hydroxide	Alkaline solvent	Cleaning and etching aluminum
Toluene	Petroleum solvent	Washing up and thinning rubber, oil, ethyl cellulose inks, and alkyd enamels
Trichloroethane	Chlorinated solvent	Washing up layout dye and screen inks Ultrasonic cleaning
Trichlorethylene	Chlorinated solvent	General-purpose cleaning and vapor degreasing
Turpentine	Petroleum solvent	Cutting machine fluid
Xylene	Petroleum solvent	Thinning acrylic printing inks Washing up synthetic enamels and photo resist ink

Lubricant	Application
WD40	General purpose lubricant
3-in-1 oil	General purpose lubricant

Objective 12

Storage of hazardous materials

a. Select an area that meets local, state, and national codes.

b. Store materials in metal cabinets.

c. Keep cabinet or storage area locked.

d. Store in an area away from open flame or excessive heat.

e. Always read labels and follow instructions for proper storage.

Objective 13

Two common hazardous materials found at electrical job sites

a. **PCB (Polychlorinated Biphenyl)**—Fire resistant; helps improve the coolant and dielectric properties of oil; can be harmful if absorbed into the skin; suspected of being cancer-causing

Note: PCBs are considered serious environmental contaminants.

b. **Asbestos**—Used in ceilings, boilers, and electrical wiring as a heat retardant; highly suspected of causing cancer

Note: OSHA requires employers to test for asbestos fibers in the air. The results determine the control measures taken to protect employees.

Objective 14

Purposes of material safety data sheets (MSDS)

a. To inform the user of the material's physical properties of fast-acting health effects that make it dangerous to handle

b. To tell the user the level of protective gear needed

c. To tell the user the first aid treatment necessary if exposed to the product or its hazards

d. To tell the management and the user preplanning needed for safely handling spills, fires, and day-to-day operations

e. To tell the user how to respond to accidents

Objective 15

Ways hazardous materials can enter the body

a. Ingestion—By mouth

Example: Swallowing paint thinner

b. Absorption—Through the skin

Example: Getting some PCB on your hands or skin

c. Inhalation—By breathing in gases, vapors, fumes, and other forms of a material

Example: Inhaling asbestos particles

Objective 16

Colors of the safety color code and their uses

Note: The following colors identify safe and unsafe conditions in the shop. Learn the color code because it could help you prevent accidents to yourself and fellow workers.

a. **Federal safety red**—Basic color for identifying

- Fire protection equipment and apparatus
- Portable containers of flammable liquids
- Emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

b. **Federal safety yellow**—Basic color for designating

- Caution and for marking physical hazards
- Waste containers for explosive or combustible materials
- Caution against starting, using, or moving equipment under repair
- Identification of the starting point or power source of machinery

c. **Federal safety orange**—Basic color for designating

- Dangerous parts of machines
- Safety starter buttons and parts of equipment that may produce electrical shock
- The exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

d. **Federal safety purple**—Basic color for designating radiation hazards

e. **Federal safety green**—Basic color for designating

- Safety
- Location of first aid equipment

Note: This applies to equipment other than fire fighting equipment.

f. **Federal safety black and white**—Basic colors for designating

- Traffic flow
- Housekeeping zones
- Storage areas

Note: Black and white colors are used individually or in combination.

g. **Federal safety blue**—Basic color for designating

- Equipment that should **not** be started, used, or moved

Examples: Defective equipment, equipment being serviced

Note: A blue tag is lettered with the words "Out of Order."

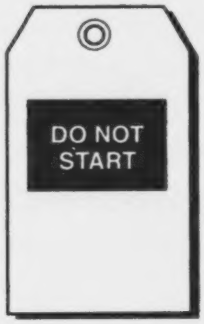
Objective 17

Color coding of safety tags or signs

a. Do not start tag

- White tag
- White letters on red square

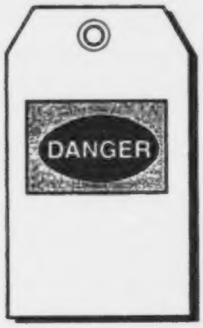
Figure 1



b. Danger tag

- White tag
- White letters in red oval, on black square

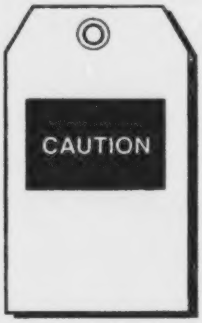
Figure 2



c. Caution tag

- Yellow tag
- Yellow letters on black background

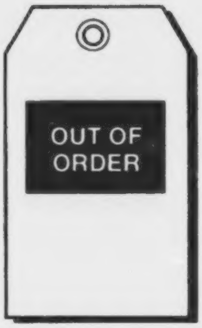
Figure 3



d. Out of order tag

- Blue tag
- White letters on black background

Figure 4



Objective 18

Components of the fire triangle

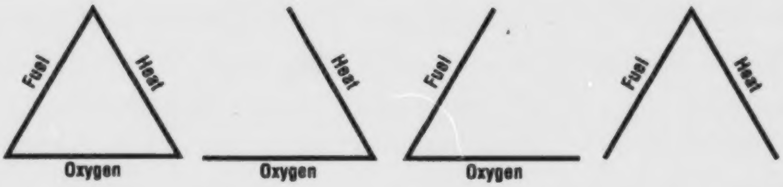
a. Fuel—Any combustible material

b. Heat—Enough to raise the fuel to its ignition temperature

c. Oxygen—Necessary to sustain combustion

Note: To produce fire, the three elements of the fire triangle must be present at the same time. If any one of the three is missing, a fire cannot be started. With the removal of any one element, the fire will be extinguished.

Figure 5



Objective 19

Types of fires and their classifications

a. **Class A**—Fires that occur in ordinary combustible materials

Examples: Wood, rags, paper, or trash

b. **Class B**—Fires that occur in flammable liquids

Examples: Gasoline, oil, grease, paints, or thinners

c. **Class C**—Fires that occur in electrical and electronic equipment

Examples: Motors, switchboards, circuit wiring, radios, or television sets

d. **Class D**—Fires that occur in combustible metals

Examples: Powdered aluminum or magnesium

Objective 20

General types of fire extinguishers and their uses

a. **Foam**—Instead of spraying stream into the burning liquid, allow foam to fall lightly on the fire; use for Class A or Class B fires.

b. **Carbon dioxide**—Direct discharge as close to fire as possible, first at the base of flames, then gradually forward and upward; use for Class B or Class C fires.

c. **Pump tank**—Place foot on foot pump and direct stream at base of flames; use on Class A fires only.

d. **Dry chemical**—Direct at the base of flames; follow up by directing the dry chemicals at remaining materials that are burning; use for Class B or Class C fires.

e. **Halon**—Direct a base of flames, sweeping from side to side; use for Class C fires.

Note: Halon is a clean, liquid gas that does not leave a residue.

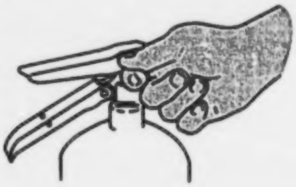
Caution: A high concentration halon gas may be hazardous to your health because it displaces oxygen in air.

Objective 21

Fire extinguisher general operating instructions that follow the letters P-A-S-S

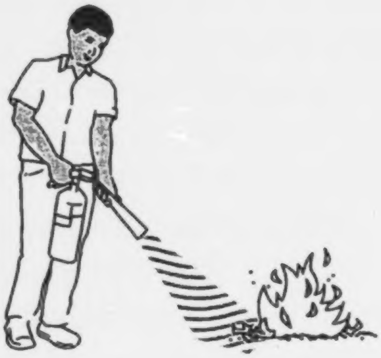
a. **P**–ull the pin at the top of the extinguisher that prevents the handle from being pressed.

Figure 6



b. **A**–im the nozzle toward the fire.

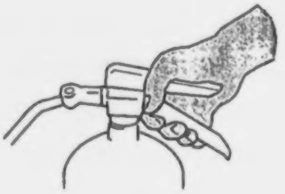
Figure 7



541

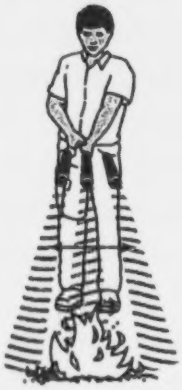
c. **S**–queeze the handle to discharge the extinguishing agent.

Figure 8



d. **S**–weep the nozzle back and forth at the base of the flames to disperse the extinguishing agent.

Figure 9



Objective 22

Contributing factors and causes of back injuries

a. **Weight**—Injury results from overestimating your physical abilities and trying to lift more weight than you can handle.

b. **Size**—Injury usually results from moving an object that may be within your weight capacity, but is too long, high, or wide to lift safely.

c. **Shape**—Injury usually results from moving an object that may be within your weight capacity, but has a cylindrical shape or other odd shape that makes safe lifting difficult.

d. **Obstructions**—Injury usually results from stacking materials so high that vision is limited and obstructions in the pathway cannot be seen.

e. **Improper position**—Injury usually results from twisting or turning to an awkward position when lifting.

f. **Improper storage**—Injury usually results in strain caused by not storing heavy objects at least 12 inches off the floor.

g. **Improper reaching**—Injury usually results from carelessly using chairs or boxes instead of safely using a ladder, or by positioning elevating object too far from work.

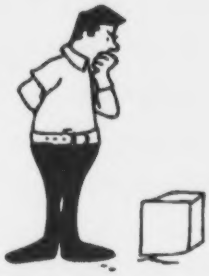
Objective 23

Guidelines for lifting and moving items safely

a. Before lifting

- Inspect the item to be lifted for jagged edges, splinters, and grease or other slippery surfaces.

Figure 10



- Wear gloves for protection, and make sure that they fit properly.
- Wear lower-back support.

  Example: Leather lower-back support belt

- Plan your route before you lift.
- Clear any obstacles from your path.
- Assess the weight of the load.
- Get help to lift heavy loads.

  Note: Teamwork works best when both persons are about the same size. The load should be distributed evenly between both workers.

- Use a dolly to move very heavy, large, or awkward loads that cannot (or should not) be lifted by two people.

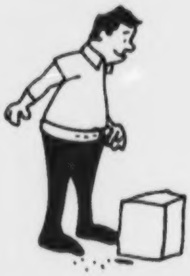
  Examples: Piano, refrigerator, sofa bed

543

b. Lifting

- Place your feet as close to the load as possible, one foot alongside the load and the other behind it.

Figure 11



- Bend your knees, keeping your back and neck straight and your chin tucked in.
- Grasp the load firmly with your fingers and hands.
- Draw your arms in close to your body.
- Stand slowly and lift smoothly, using your legs.

Figure 12

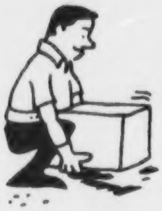
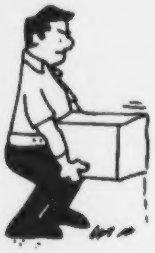


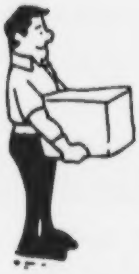
Figure 13



c. **Carrying**

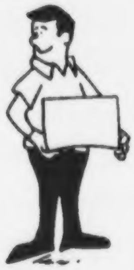
- Hold items close to your body.

Figure 14



- Do not allow load to block your vision.
- Do not change your grip or twist your body to change direction.

Figure 15

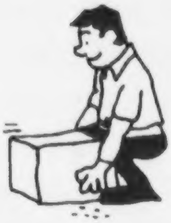


Note: Twisting the back while carrying a load (even a small one) can result in severe back injury

c. **Setting down the load**

- Bend your knees.
- Keep your back and neck straight and aligned.
- Place load carefully where you want it, taking care not to allow it to rest on your feet or fingers.

Figure 16



Objective 24

Guidelines for preventing slips, trips, and falls

a. Wipe up spills immediately.

b. Post warning signs when floors are wet.

c. Use handrails on stairs.

d. Report any tripping hazard.

Examples: Loose boards, loose tiles, broken steps, torn or curled carpets

e. Do not leave equipment, materials, or other obstacles in hallways, on stairs or landings, before doors and exits, or in any other area where people may trip over them.

f. Do not stretch extension cords across traffic areas.

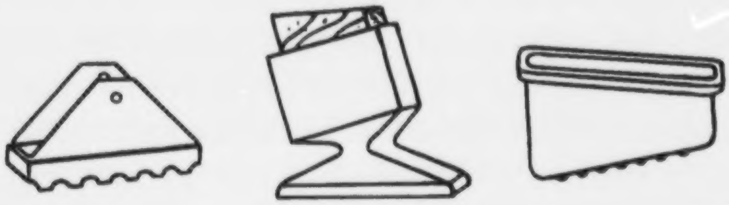
g. Use a ladder instead of a chair or box to reach high objects or areas.

Objective 25

Rules for using ladder safely

a. Make sure the ladder has non-skid safety shoes.

Figure 17



b. Inspect the ladder before use for worn safety shoes, broken or loose rungs/steps, or other defects.

c. Inspect the ladder rungs/steps and siderails for oil or other slippery materials before you climb.

d. Never use metal ladders for electrical work.

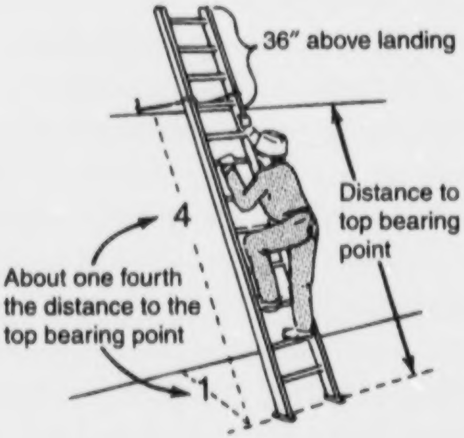
e. Locate the ladder away from doors or other openings that are not blocked or guarded.

f. Place ladder feet on a level, non-skid surface.

g. Place ladder at a safe angle to the work: at least 1 foot from the wall for every 4 feet of height.

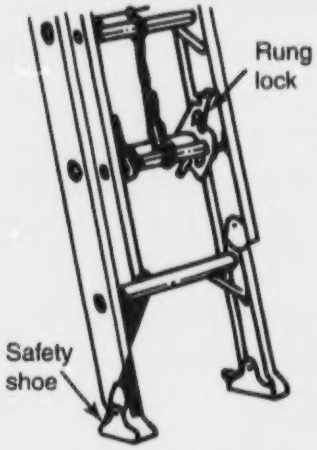
Note: Get help in carrying and raising heavy or long ladders.

Figure 18


36" above landing
Distance to top bearing point
4
About one fourth the distance to the top bearing point
1

h. Use rung locks to secure the sections of extension ladders.

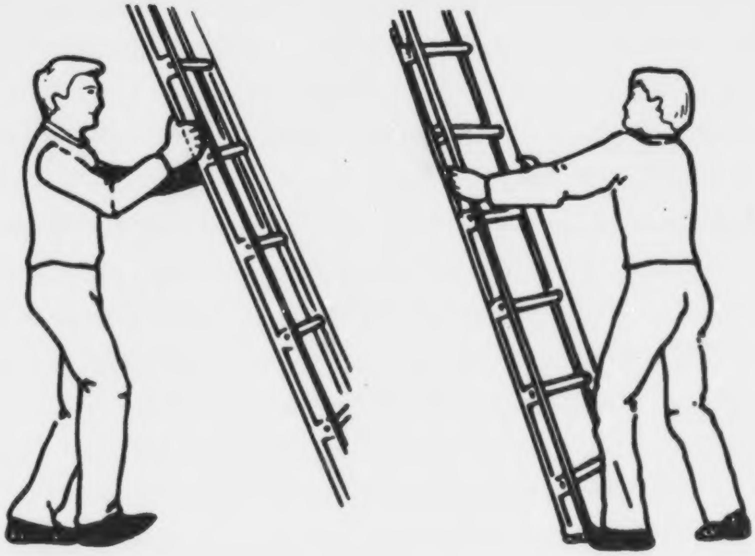
Figure 19


Rung lock
Safety shoe

i. Place top of extension and straight ladders at least three rungs above the work.

j. Get a helper to heel straight or extension ladders.

Figure 20



k. Face the ladder when climbing up and down.

l. Never stand on the top rung/step.

m. Do not overextend your reach while on the ladder; descend the ladder and reposition it instead.

n. Allow only one person on the ladder at a time.

o. Do not use ladders for makeshift scaffolds.

p. Store ladders securely when not in use.

Objective 26

Safety guidelines for using scaffolds

a. Never climb a scaffold unless all four scaffold legs are on the ground.

b. Secure scaffold wheel locks before climbing.

c. Get help when assembling the scaffold.

d. Never ride the scaffold when it is being moved.

e. Always use proper planks when assembling.

f. Always read manufacturer's instructions before constructing scaffolds.

Objective 27

Safety guidelines for using power lifts

a. Never lift over the weight-rated capacity of the lift.

b. Operate lift on smooth surfaces if possible.

c. Always check for objects in the pathway.

d. Never put arms or legs in lift.

e. Always use caution when moving lift.

Objective 28

General steps for handling any emergency situation

a. **Step 1:** Determine the type of emergency.

b. **Step 2:** Notify the appropriate medical or law-enforcement authority.

Examples: Ambulance, fire department, police

c. **Step 3:** Notify your supervisor.

d. **Step 4:** Provide basic first aid, or seek assistance from others until proper authorities arrive.

Objective 29

General guidelines for first aid emergencies

a. Before administering first aid, always have a reason for what you do.

b. Reassure the injured person that everything possible is being done.

Note: Hearing the concerned voice of a co-worker is psychologically comforting to an injured person and can actually lessen the degree of traumatic shock.

c. Make accurate notes about the accident, including the victim's name, the time, place, cause or nature of the accident, and any first aid that was administered.

d. Do not notify the victim's family; this is the responsibility of the school, the job site supervisor, or the medical facility.

e. Report all accidents and injuries to your instructor or job site supervisor, no matter how minor they may seem.

Information Sheet

Objective 30

Descriptions of basic first aid procedures for various emergency situations

Note: In the event of severe injury or illness, notify your supervisor, call an ambulance, paramedics, or a doctor, and give the victim basic first aid until help arrives.

> **Caution:** Given the increased awareness of diseases carried by bloodborne pathogens, hepatitis B (HBV), human immunodeficiency virus (HIV) and others, the U.S. Department of Labor advises that universal precautions be observed any time blood or other human body fluid is present. This precaution requires employers and employees to assume that all human blood and specified human body fluids are infectious for HIV and HBV and other bloodborne pathogens. Where it is impossible to determine the type of body fluid presents, all body fluids are to be considered

a. **Eye injury**

- Minor—Have the victim close his or her eyes; put a piece of moist cotton over the closed lid; place a bandage over the cotton; get the victim to a doctor as soon as possible.

- More severe injury—Apply a sterile dressing, bandage loosely, and get medical help immediately.

  Note: Never permit the victim of an eye injury to rub his or her eye. Even though damage may be confined to one eye, it is sometimes best to bandage both eyes with a sterile dressing so the victim will not have a tendency to move the damaged eye.

- Chemical injury—Flush eyes immediately at an eye-flushing station, or use a bottled, portable flushing solution; then seek immediate medical assistance.

b. **Bleeding**

- Minor bleeding—Apply antiseptic solution or cream and dress wound with sterile bandages.

- Severe bleeding—Elevate the wound and apply pressure dressing or manual pressure to the wound.

c. **Burns**

- Chemical—Flush skin thoroughly with clean water and seek medical attention.

- Electrical—Locate both the entrance and exit burns; cool with a damp compress, then cover with dry sterile dressing; cover the victim with a blanket and elevate the feet and legs to prevent shock and loss of body heat.

- First-degree—Hold under cold water, then apply dry sterile dressing.
- Second-degree—Cool with a damp compress, taking care not to break the blisters, then cover with a dry, sterile dressing to prevent infection.
- Third-degree—Cool with a damp compress and then cover with a dry sterile dressing; cover the victim with a blanket, elevate feet and legs to prevent shock and loss of body heat.

d. **Traumatic shock**

Note: Traumatic shock may occur within any time period following an injury. Although the injury itself may not be life threatening, the onset of shock resulting from the injury can be fatal.

- Recognize signs and symptoms of traumatic shock.
  - Early stages
    - Pale or bluish skin that is cool to touch
    - Moist, clammy skin if perspiration has occurred
    - General weakness
    - Rapid, weak pulse
    - Rapid, shallow, possibly irregular breathing
    - Restlessness or anxiety
    - Vomiting or nausea
    - Excessive thirst
  - Late stages
    - An attitude of not caring
    - Unresponsiveness
    - Sunken eyes with dilated pupils
    - Spotty or mottled appearance of skin; bluish color to lips and nailbeds
    - Low body temperature; cool clammy skin
    - Loss of consciousness leading to death if untreated
- Lay victim down.
- Elevate victim's legs slightly.
- Cover to prevent loss of body heat.

Note: In some cases it may be necessary to have someone lie in close contact with the victim to conserve body heat.

e. **Falls**

- Head injury—Lay victim flat, then control bleeding and shock.
- Less severe falls—Check for injury and provide first aid as appropriate; do not move victim or allow victim to move if a neck or back injury is suspected.

> **Caution:** If either neck or back is broken, moving the victim could sever or damage the spinal cord, causing immediate death or paralysis.

f. **Electrical accident**

> **Caution:** If the victim is still in contact with a live electrical circuit, do not endanger yourself by touching the victim, or metal objects, water, or wet ground. You may become a victim yourself as the current passes through your body. Death can be instantaneous.

- Do not provide any assistance until all electrical current has been shut off.
- Administer CPR if necessary.
- Treat for traumatic shock.
- Treat for electrical burns.

Note: Always look for the entrance wound and exit wound of an electrical burn. Both may resemble a bull's-eye consisting of a central charred zone, a middle zone of gray tissue, and an outer red zone.

g. **Heat exhaustion**

- Recognize the signs and symptoms of heat exhaustion:
  - Profuse perspiration
  - Pale, clammy skin
  - Rapid, weak pulse
  - Rapid, shallow breathing
- Immediately move victim to a cool place.
- Lay victim flat.
- Elevate victim's feet slightly.

- Remove as much of the victim's clothing as possible.
- Sponge victim with cool water.

h. **Heat stroke**

Note: Heat stroke is a true emergency. Act quickly or the victim will suffer brain damage or death.

- Recognize the signs and symptoms of heat stroke:
  - Little or no perspiration
  - Hot, flushed skin
  - Rapid, weak pulse
  - Rapid, shallow breathing
- Move victim immediately to a cool location.
- Cool victim as quickly as possible.

  Note: Do not take time to remove a victim's clothing until after initial cooling, such as spraying the victim with a garden hose, pouring the contents of a drinking water container over the victim, or immersing victim in a nearby stream or pond.
- Rub ice on victim's extremities.

i. **Mild hypothermia**

- Recognize the signs and symptoms of mild hypothermia:
  - Shivering
  - Complaints of being cold
  - Loss of coordination
  - Psychological withdrawal and apathy
- Get the victim out of cold, wet conditions.
- Replace wet clothing with dry clothing, or add insulation.
- Place victim in warm environment.
- Offer warm liquids or food only if victim is fully conscious.

j. **Moderate hypothermia**

- Recognize the signs and symptoms of moderate hypothermia:
    - Listlessness, mental confusion, refusal to recognize problem
    - Uncontrollable shivering
    - Slurred speech
    - Stumbling
- Cover victim at the site rather than walking to shelter.
- Treat victim gently and avoid unnecessary jostling or movement.
- Do not allow victim to exercise or move.
- Check victim for other injury, including frostbite.

k. **Severe hypothermia**

- Recognize the signs and symptoms of severe hypothermia:
    - Unresponsiveness
    - Decreased pulse and respiration
    - Cessation of shivering
    - Physical collapse
- Treatment should be attempted only if victim cannot be evacuated for professional emergency care.
- Deliver warmth to head, neck, armpit, and groin areas by application of warm water bottles, warmed blankets, or another warm body.

l. **Animal bite**

Note: First aid for animal bites is similar to any other wound, except for the need to be aware of the possibility of rabies infection.

- Cleanse wound thoroughly with soap and water; apply antiseptic.
- Cover bite wound with a sterile dressing and bandage.
- Seek medical attention, especially if the bite is on the face, head, or neck areas.

m. **Insect stings**

Note: In case of a bee sting, the insect's stinger likely will still be imbedded in victim's skin. Scrape stinger sideways to remove. Never pinch the stinger to remove as this actually will inject more toxin into the wound.

- Ordinary reaction—Wash wound with soap and water and apply ice to reduce swelling
- Allergic reaction

  Note: A victim with an allergic reaction to a bee sting is suffering from anaphylactic (respiratory arrest) shock and needs prompt treatment with epinephrine by injection or inhalation.

  — If possible, immediately evacuate the victim to a hospital or physician's office.

  Note: Have someone call ahead to notify the party of the situation and your planned arrival.

  — If transportation is not immediately available, lay the victim down or help the victim to a position in which he or she can breathe more easily.

  — Elevate the victim's legs if possible.

  — While waiting for emergency aid, remove the stinger and perform first aid actions for an ordinary sting.

n. **Snake bite**

- Nonpoisonous

  — Cleanse wound with plain water and soap.

  — Cover with sterile dressing.

  — Seek medical attention.

- Poisonous—Pit viper

  Note: Within the medical community there is a vigorous controversy over the advisability of using antivenin injections in the treatment of snake bites originating from copperheads, rattlesnakes, and cottonmouth (water moccasin). Although in the case of the coral snake, antivenin treatment is recommended, because of the conflicting opinions on the use of similar materials for pit viper bites, professional medical assistance is advisable and decisions on the use of antivenin should be left up to those professional individuals.

- Immobilize the victim.
- Have him or her lie down, and keep quiet.
- Do not give victim liquor.
- Apply a constricting band about the affected appendage just above the fang marks as soon as possible.

  Note: Under no circumstances should the constricting band be tight enough to block venous or arterial blood flow. Also, as edema (tissue swelling due to concentrations of water and waste material) builds, the band should be moved further from the wound periodically.

- Apply suction as quickly as possible to wounds to remove venom.

  Note: Suction cups, "Extractor" devices, and mouth suction (be aware of cautions on bloodborne pathogens) are recommended to remove as much venom as possible. Suction should be continued up to four hours after the bite, although the amount of venom removed by this method will be sharply reduced after the first 15 minutes. Still, as pit viper venom degenerates tissue and blood cells near the wound, suction removal of this waste material will be helpful in preventing the victim's body from having to filter this material through the lymphatic and renal systems.

- Apply hot and cold compresses, alternated every three to five minutes.

  Note: Raising the temperature of venom tends to break it down, and lowering temperatures tend to cause the capillary system to contract. The continual differing stimuli help provide fresh oxygenated blood flow to the wound area and tend to prevent additional tissue damage.

- Seek medical attention at once.

- Poisonous—Coral snake

  Note: The venom of the coral snake is similar to that of the cobra in that it attacks the nervous system, unlike venom of pit vipers which attacks the blood and circulatory system. Because of this immediate medical attention and administration of antivenin is necessary. Death can come rapidly.

- Immobilize the victim. Have him or her lie down and keep quiet.
- Apply arterial tourniquet (tight enough to stop blood flow) up to 30 minutes.
- Seek medical attention at once for antivenin administration.

o. **Tick bites**

- Carefully remove an imbedded tick with tweezers by grabbing the tick as close to the skin as possible and pulling gently straight out.

  Note: Removing the tick with the thumb and forefinger carries the risk of crushing the tick and actually injecting the victim with the juices of the tick.

- Wash area with soap and water.

- Use a topical antiseptic and be alert for signs of tick-borne diseases for several weeks.

  Note: Some ticks are carriers of Lyme disease and Rocky Mountain Spotted Fever.

p. **Spider bites**

- Apply cold water or ice; a topical antiseptic may be used; take aspirin or acetaminophen for pain; and rest.

  Note: The bite of either the black widow or brown recluse spider is highly toxic and dangerous. If bitten by either of these species (or if you are not certain of the biting spider's identification) seek medical attention at once.

q. **Choking**

- Recognize the signs and symptoms of choking:
  - Victim clutches throat (universal sign of choking)
  - Victim has trouble speaking or breathing
  - Skin turns pale or bluish
  - Victim loses consciousness
- Perform the Heimlich maneuver

r. **Heart attack**

- Recognize the signs and symptoms of heart attack:
  - Chest pain that may radiate to the arms, neck, jaw, and upper back

    Note: Chest pain is the most important symptom of heart attack. It is reported in 80 to 90 percent of heart-attack victims.

- Profuse sweating and chills
- Nausea and vomiting
- Difficulty and pain in breathing
- Weakness
- Apprehension

Note: A victim of heart attack will often feel as though he or she is going to die.

- Help victim to a less painful position.
- Loosen victim's clothing around the neck and midriff.
- Apply CPR if required and you are qualified.

s. **Seizure**

- Help victim lie on the ground or floor if possible.
- Do not try to restrain victim.
- Clear area of hard or dangerous objects to protect the victim from self-injury.
- Remove victim's eyeglasses, if applicable, and loosen clothing in the head and neck area.
- Turn victim to the side to allow saliva to drain from the mouth.
- Transport victim to a hospital or doctor's office after seizure has passed.

Student Supplement 1—Complete the Student Safety Pledge Form

Complete the student safety pledge form and return it to the instructor.

______________________________, who is enrolled in

Vocational ______________________________, will as a part of his/her shop experience, operate machines, providing that the parent or guardian gives written permission.

It is important that each student be given proper instruction, both in the use of the equipment and in correct safety procedures concerning it, before being allowed to operate it. The student must assume responsibility for following safe practices, and we therefore ask that the student subscribe to the following safety pledge.

I promise to follow all safety rules for the shop.

I promise never to use a machine without first having permission from the instructor.

I will not ask permission to use a particular machine unless I have been instructed in its use, and have made 100% on the safety test for that machine.

I will report any accident or injury to the teacher immediately.

Date ________________ Student Signature ____________________

I hereby give my consent to allow my son or daughter to operate all machines and equipment necessary in carrying out the requirements of the course in which he or she is enrolled.

Date ________________ Parent's Signature ____________________

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

Student Supplement 2—Guidelines for Interpreting Material Safety Data Sheets

This supplement was prepared in conjunction with Assignment Sheet 1, and should be read and understood prior to attempting that assignment.

Living in the modern world, you probably are aware that the use of chemicals offers convenience and progress at home and work. Naturally, you want to avoid dangerous overexposure to chemicals, especially on the job. Such overexposure is possible no matter where you work, even in an office or light industry.

Your company's hazard communications, or HazCom, program was created to protect your health and safety. Three important elements are at the heart of your HazCom program: warning labels on containers, training on the safe use and handling of chemicals, and material safety data sheets (MSDSs).

What is on an MSDS

MSDSs are printed pages that give you all the critical information you need about how to use, transport, and store chemicals in order to protect yourself, as well as what to do in case of emergencies and overexposure. Information on MSDSs includes:

- The chemical's name or names
- Name, address, and phone number of the manufacturer
- List of the chemical's ingredients
- Permissible exposure limits (PEL) or threshold limit value (TLV)
- What conditions or other substances will cause the chemical to catch fire, explode, melt, or turn into dangerous gases
- How the chemical usually looks and smells
- How to put out a fire involving the chemical
- What to do if the chemical spills or leaks
- How to prevent dangerous exposure
- Health hazards such as skin irritant or cancer-causing agent
- Symptoms of overexposure
- What to do if you are overexposed
- When the MSDS was prepared

The information for each chemical's MSDS is put together by the manufacturer or distributor for that chemical. The sheets often look different from each other, but they still provide the same information. The law requires your employer to keep MSDSs up to date and to send the MSDS to your doctor or designated representative if you request it.

Where the MSDS is kept

MSDSs must be readily accessible to employees—a posted sign may tell you where, and you can also find out by reading your company's written HazCom program. If you are not sure where to find MSDSs, your supervisor or your company's HazCom contact will make them available to you. It is the law.

When to read an MSDS

You should always read the MSDS before you begin a job using a chemical. Even if you have used the chemical before, the manufacturer may have changed its formula, which may change the steps you should take to protect yourself. Taking proper precautions listed on the MSDS, such as wearing a respirator, can prevent serious long-term illnesses.

If you do not understand something on the MSDS, or have questions about your company's HazCom program, ask your supervisor or company contact. Your company knows that HazCom works best if you are fully informed and involved.

How to read an MSDS

The material safety data sheet, or MSDS, is written information that can help protect you from overexposure to chemicals you find on the job. The MSDS is part of your company's hazard communications program. Each company can design its own MSDS form, and the sections may be in a different order. But the basic kinds of information on any MSDS will be the same.

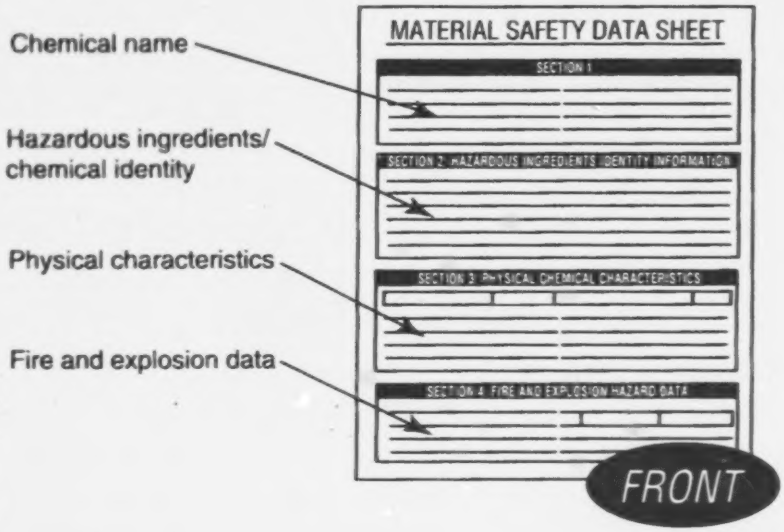
Chemical name (see Figure 1). Lists the identity of the substance (the name on the label, date the MSDS was prepared, the name and address of the manufacturer, and usually a phone number for emergencies and more information).

Hazardous ingredients/chemical identity (see Figure 1). Includes names of substances in the chemical that might be dangerous, and lists safety exposure limits such as permissible exposure limit or PEL (set by OSHA) or the threshold limit value or TLV. Also lists common names for the chemical.

Physical characteristics (see Figure 1). Describes many physical qualities of the chemical, and lets you know what is usual or safe. For example, how the chemical looks and smells; boiling and melting temperatures (important in case a chemical might become a gas you could breathe); evaporation rate (known as percent volatile); how easily the chemical dissolves; and how heavy it is (this tells you if it will sink, float, or dissolve in water).

Student Supplement 2

Figure 1


MATERIAL SAFETY DATA SHEET
SECTION 1
SECTION 2 HAZARDOUS INGREDIENTS IDENTITY INFORMATION
SECTION 3 PHYSICAL CHEMICAL CHARACTERISTICS
SECTION 4 FIRE AND EXPLOSION HAZARD DATA
FRONT

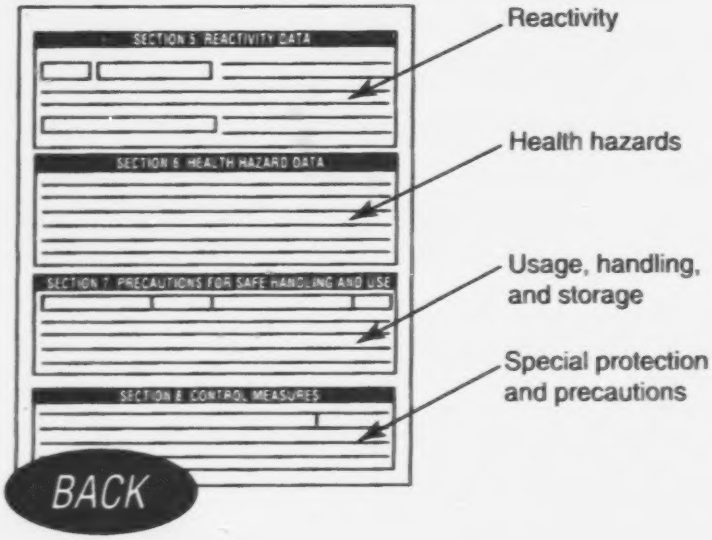
Chemical name

Hazardous ingredients/ chemical identity

Physical characteristics

Fire and explosion data

Figure 2


SECTION 5 REACTIVITY DATA
SECTION 6 HEALTH HAZARD DATA
SECTION 7 PRECAUTIONS FOR SAFE HANDLING AND USE
SECTION 8 CONTROL MEASURES
BACK

Reactivity

Health hazards

Usage, handling, and storage

Special protection and precautions

Fire and explosion data (see Figure 1). Tells you the lowest temperature at which the chemical could catch fire (flash point). Lets you know if it is flammable (catches fire below 100°F) or combustible (catches fire above 100°F). Lists the best way to put out a fire involving that chemical.

Reactivity (see Figure 2). Describes what happens if this chemical comes in contact with air, water, or other chemicals. Describes conditions (like heat) or materials (like water) that can cause the chemical to react by burning, exploding, or releasing dangerous vapors. The chemical is called "incompatible" or "unstable" with these conditions or substances.

Health hazards (see Figure 2). Lists ways the chemical might enter your body, like splashing on your skin or being breathed in as vapor, as well as possible symptoms of overexposure. Lets you know if overexposure might make existing medical conditions worse, and describes emergency first aid procedures.

Usage, handling, and storage (see Figure 2). Describes how to clean up an accidental spill, leak, or release, including special procedures. Tells you how to handle, store, and dispose of chemicals safely. Remember, if there is an accident, notify your supervisor immediately. Take care of it yourself only if you are trained to do so and are wearing the proper equipment.

Special protection and precautions (see Figure 2). Explains special personal protective equipment (PPE) and other equipment to use when working with the chemical, special procedures, extra health or safety information, signs that should be posted, and other information not covered in other sections.

Terms and abbreviations used on MSDSs

The following terms and abbreviations will help you interpret material safety data sheets.

- **TLV**—Threshold limit value; a time-weighted average concentration under which most people can work consistently for 8 hours a day, day after day with no harmful effects

- **Ceiling**—Uppermost limit

- **ACGIH**—American Conference of Governmental Industrial Hygienists

- **OSHA**—Occupational Safety and Health Administration

- **PEL**—Permissible exposure limit; the maximum time-weighted concentration *at which* 95 percent of exposed, healthy adults suffer no adverse effects over a 40-hour week

- **ppm**—Parts per million

- **STEL**—Short-time exposure limit; a 15-minute, time-weighted average that should not be exceeded at any time during a workday. Exposures at STEL should not be longer than 15 minutes and should not be repeated more than four times a day with at least 60 minutes between exposures.

- **IDLH**—Immediately dangerous to life and health; material *at* or *above* this level poses an immediate hazard to life or produces immediate, irreversible, debilitating effects
- **LEL**—Lower explosive limit; below the flammability range (too lean to burn)
- **UEL**—Upper explosive limit; above the flammability range (too rich to burn)

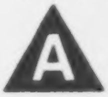
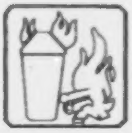
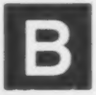
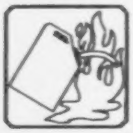
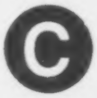
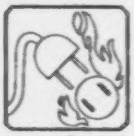
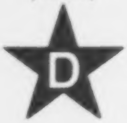
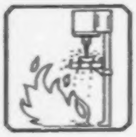
© 1988 Parlay International.

Student Supplement 3—Using Portable Fire Extinguishers

This supplement was prepared in conjunction with Assignment Sheet 3, and should be read and understood prior to attempting that assignment.

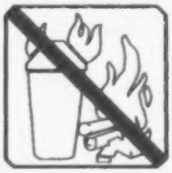
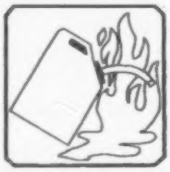
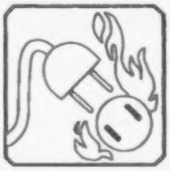
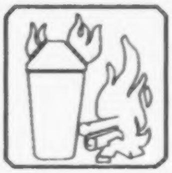
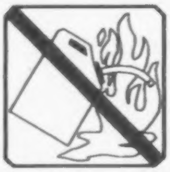
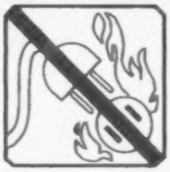
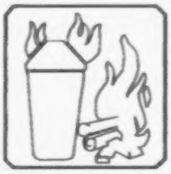
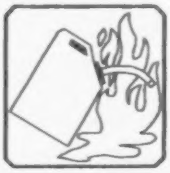
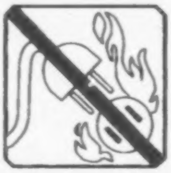
All portable fire extinguishers are labeled with picture and shape symbols. Each of the shape symbols (triangle, square, circle, and star) contains the letter of the fire class for which the extinguisher is effective. The picture symbols not only illustrate what type(s) of fire the extinguisher may be used on, but also tell what class(es) of fire the extinguisher should **not** be used on. All this information, as well as directions for using the extinguisher, are printed on the extinguisher. However, when a fire is discovered, speed is important, and, as the saying goes, "a picture is worth a thousand words." You should be able to glance at the symbols on an extinguisher and know immediately whether the extinguisher is appropriate for the fire on hand.

Below are examples of fire-class shape symbols and their meanings, and examples of extinguisher picture symbols and their meanings.

Class A (Green)  • Ordinary combustibles 	**Class B** (Red)  • Flammable liquids and gases 
Class C (Blue)  • Live electrical equipment 	**Class D** (Yellow)  • Combustilbe metals 

Student Supplement 3

Below are examples of extinguisher markings indicating extinguishers that are unsuitable for use on class A, B, or C fires.

			Picture symbols for extinguishers suitable for Class B and C fires, but **not** for Class A fires.
			Picture symbols for extinguishers suitable for Class A fires, but **not** for Class B and C fires.
			Picture symbols for extinguishers suitable for Class A and B fires, but **not** for Class C fires.

Student Supplement 4—A Systematic Look at First Aid

First aid can be defined as "immediate temporary care given the victim of an accident or suddenness or trauma until the services of a physician can be obtained."

The goal of first aid is to intervene actively to prevent further damage, to provide life support, and to begin effective treatment of the victim's condition, to minimize injury and prevent death. Although first aid is not a substitute for medical care, those trained in first aid are able to assess the nature and extent of an emergency and determine the best course of action to take until professional medical help arrives.

Scene Survey

First aid begins with a scene survey. Before approaching a victim, a survey of the area is necessary to determine if conditions surrounding the incident may place the victim and the rescuer in danger.

Primary Survey

Next, the primary survey will determine if lifesaving procedures must be immediately performed to save the victim's life. The primary survey involves checking the ABCs:

a: Is the AIRWAY open and the victim's neck stabilized?

The severity of spinal cord injuries has decreased 30-45 percent since awareness that the neck of an accident victim must be stabilized (support or immobilized) before moving the victim.

b: Is the patient BREATHING?

c: Is the victim's blood CIRCULATING? Is there a pulse? Or is there active bleeding?

Lifesaving procedures, including cardipolumonary resuscitation (CPR) may be needed to provide basic life support when a victim has no pulse and is not breathing. The Heimlich maneuver aids chocking victims by forcing ejection of obstructing material from the windpipe.

Secondary Survey

The secondary survey is a total body examination, a pulse check, respiration count (breaths per minute), and observation of skin conditions. **For electrical shock victims, this would be the time to search for both entrance and exit wounds.**

For severe medical problems, such as heart attack, stroke, or internal bleeding, the only outward sign of problems may be shock. Those in shock will have pale, cool and clammy skin; a rapid and weak pulse (over 100 beats per minute); more than 20 breaths per minute; weakness; and confused behavior. Treatment involves minimizing body heat loss, elevating the legs without disturbing the rest of the body, and getting help as quickly as possible.

Unit 3 Electrical Safety

Unit Contents

Student Components

Student Page

Learning Activities Sheet 3–3
Objective Sheet 3–5
Information Sheet 3–7

Student Supplement

1—Lockout/Tagout Procedures for Electrical Equipment 3–15

* Focus Assignment

Read About Controlling Electrical Hazards 27

* Assignment Sheets

1—Identify and Describe Safety Violations 35
2—Solve Problems Concerning Electrical Safety Practices 37

* Focus Assignment and Assignment Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "Read About Controlling Electrical Hazards."

☐ 4. **Stop** Ask instructor to evaluate the completed focus assignment. After work has been evaluated, follow instructor's recommendations.

☐ 5. **Study** Information Sheet, Objectives 1 and 2.

Optional ☐ 6. **View** Videotapes entitled: "Basic Electrical Safety On The Job Site", and "Electricity Can Kill."

☐ 7. **Study** Information Sheet, Objectives 3 through 7.

Optional ☐ 8. **View** Videotape entitled: "The Importance Of Grounding."

☐ 9. **Study** Information Sheet, Objective 8.

Optional ☐ 10. **View** Videotape entitled: "Ground Fault Circuit Interrupter."

☐ 11. **Study** Information Sheet, Objective 9, and Student Supplement 1, "Lockout/Tagout Procedures For Electrical Equipment."

Optional ☐ 12. **View** Videotape entitled: "Hazardous Energy Source-Lockout/Tagout."

☐ 13. **Do** Assignment Sheet 1, "Identify and Describe Safety Violations."

☐ 14. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, review objectives 1 through 9, and repeat step 13.

Learning Activities Sheet

☐ 15. **Study** Information Sheet, Objectives 10 and 11.

Optional

☐ 16. **View** Videotapes entitled: "The Shock Emergency", and "Emergency Response."

☐ 17. **Do** Assignment Sheet 2, "Solve Problems Concerning Electrical Safety Practices."

☐ 18. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, review objectives 1 through 11, and repeat step 17.

☐ 19. **Check** With instructor for any additional assignments to be completed.

☐ 20. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 21. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify electrical hazards and practice basic electrical safety. The student should demonstrate these competencies by completing the focus assignment and assignment sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to electrical safety with their definitions.
2. List major causes of electrical accidents.
3. Select true statements about electrical safety practices.
4. Complete statements concerning electrical fire prevention practices.
5. Select true statements concerning safety practices around live circuits.
6. Select true statements concerning proper grounding.
7. List facts about the importance of the third wire.
8. Describe ground-fault circuit-interrupters.
9. List instances when lockout devices should be used.
10. Select words to complete statements about electrical shock.
11. Select facts about treating a victim of electrical shock.
12. Read about controlling electrical hazards. (Focus Assignment)
13. Identify and describe safety violations. (Assignment Sheet 1)
14. Solve problems concerning electrical safety practices. (Assignment Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Ampere**—Unit of measure for electrical current of intensity of electron flow

b. **Conductor**—Material through which electrons flow easily

Example: An current-carrying device such as a wire or copper bar

c. **Cube tap**—A device that plugs into a receptacle and provides space for connection of two or more attachment plugs

d. **Current**—Electron flow through a conductor

e. **Ground**—Electrical point on any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

f. **Grounded**—Connected to earth or to some conducting body that serves in place of the earth

g. **Ground-fault circuit-interrupter**—Breaker or device designed to protect individuals and equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 ampere

h. **Hertz**—One complete positive or negative cycle in an alternating current circuit

i. **Hydraulic**—A system by which equipment is powered by liquid (hydraulic fluid)

j. **Multi-outlet assembly**—A type of surface or flush raceway designed to hold conductors and receptacles

k. **Ohm**—Unit of measure for electrical resistance

l. **Pneumatics**—A system by which equipment is powered by air

m. **Volt**—Unit of measure for electrical pressure

Objective 2

Major causes of electrical accidents

a. Rushed or distracted personnel (carelessness)

b. Failure to verify that equipment was deenergized

c. Misuse of tools or equipment

Information Sheet

Objective 3

Basic electrical safety practices

a. Never underestimate the danger of 110-volt AC circuits.

Note: The small number of worldwide electrical accidents that prove fatal–about 1,000 per year over the past 15 years–is due to the general recognition that electricity is inherently dangerous. However, more people die from 110-volt electrical shock than from any other voltage. This statistic is mostly due to those individuals who make the false assumption that 110-volt current is not dangerous and does not pose a lift-threatening hazard.

b. Watch out for electrical arcs; they can cause bad burns.

c. Do not operate equipment beyond its rated capacity.

d. Never install equipment that will overload a circuit.

e. Never bypass a fuse.

f. Be sure that all current-carrying electrical lines are well insulated.

g. Always check a circuit for voltage before servicing.

h. Know where all emergency shutdown switches are located.

i. Work on live (energized) circuits only when absolutely necessary.

j. Look for burned wires on electrical devices.

k. Never touch a conductor without first testing.

l. Look for loose conductors in electrical systems.

m. Do not make any adjustment or repairs to any electrical equipment until all the power has been disconnected or the electrical breaker has been turned off.

Note: Adjustments or repairs should be performed only by authorized persons.

n. Properly ground all electrical equipment and tools to prevent injury to the operator.

o. Do not operate electrical parts while wearing wet gloves or wet clothing.

Note: To prevent harmful body shocks, keep hands, feet, and clothing dry, and use a dry board or rubber mat when water, moisture, or perspiration cannot be avoided.

p. Never work alone when working with more than 50 volts.

Objective 4

Electrical fire prevention practices

a. Use extension cords only within their designated rating.

b. Never let multi-outlet assemblies or cube taps cause overloads.

c. Never use frayed or deteriorated extension cords.

d. Never tamper with fuses to change their current-carrying capacity.

Objective 5

Safety practices around live circuits

a. Use a reliable circuit tester or voltmeter to identify live circuits.

b. Stand on a dry surface.

c. Use only one hand when possible.

d. Never leave tools lying near conductors.

e. Wear suitable insulated hand covering.

f. Return all tools to your pouch when through with them.

Objective 6

Proper grounding

a. Always check electrical equipment for proper grounding before working on it.

b. Proper grounding allows the fault current to clear the overcurrent device, thus providing safe operations.

c. Properly grounded equipment provides a pathway for stray current that may otherwise go through the operator's body.

d. Loose wires that touch a case or housing in electrical equipment can cause electrical shock to anyone who touches the equipment if it has not been properly grounded.

e. Loose connections can be detected by heated or discolored conductors, a burning odor, or carbon tracking.

Objective 7

Importance of third wire

Note: To avoid electrical shock, always check for a third wire (ground wire) before using electrical equipment.

a. It is installed for personal protection.

b. It provides an alternate path for current in case of a short.

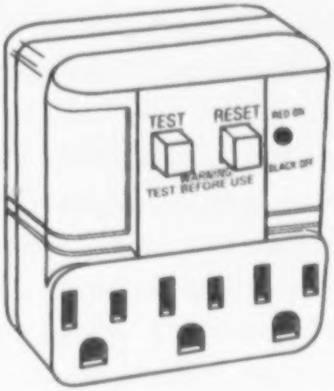
c. It can save a person's life.

Information Sheet

Objective 8

Ground-fault circuit-interrupters (GFCI)

Figure 1



a. Are personal safety devices designed to protect individuals or equipment by deenergizing or tripping a circuit when current to ground reaches 0.005 ampere

b. Are required on 15-and 20-ampere receptacle outlets used for temporary power supply at construction sites

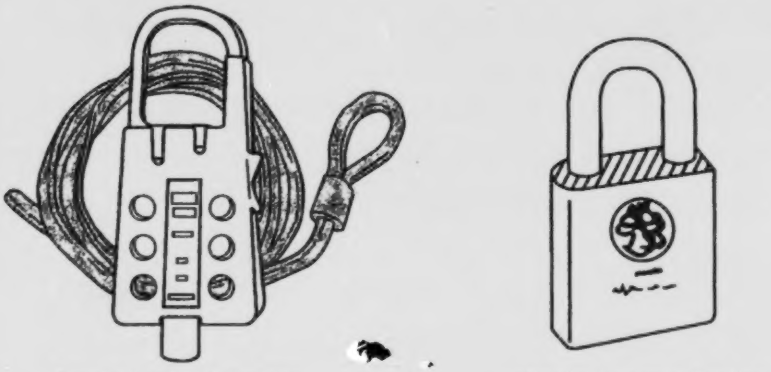
Note: See Unit 15, "Overcurrent Protection," Objective 8, for a list of installations that require ground-fault circuit-interrupters.

c. Interrupt flow of current in substantially less time than a normal overcurrent device will

Objective 9

When to use lockout devices

Examples: Figure 2



Group Lockout Device

Single Lockout Device

a. Use when more than one power source is present.

b. Always use when hydraulic position could change.

c. Always use when pneumatic position could change.

d. Use to lock off all electrical devices before working on equipment.

Objective 10

Facts about electrical shock

a. High voltage (low current) tends to knock the victim away from the circuit, minimizing exposure time.

b. High current tends to cause the body to adhere to the circuit, so that the victim cannot let go.

- At about 1 milliampere (0.0010 ampere), a single shock will be felt.
- At about 10 milliamperes (0.010 ampere), the shock is severe enough to paralyze muscles, and a person may not be able to let go of the conductor.
- At about 100 milliamperes (0.1 ampere) the shock is usually fatal if it lasts 1 second or more.

Note: Human body resistance varies from about 500,000 ohms when dry to about 300 ohms when wet. Because of this, voltages as low as 30 volts can cause enough current to be fatal. Any circuit with a potential of at least 30 volts must be considered dangerous.

Objective 11

Treating the victim of electrical shock

a. Safely remove victim from contact with the source of electricity using the following procedure:

> **Caution:** Do not touch the electrical circuit or the victim unless the power is off or you are insulated.

- Turn off the electricity, using a switch or circuit breaker, or cut cables or wires with a wood-handled axe or insulated cutters.

> **Caution:** Be aware that throwing the circuit breaker on systems with auxiliary or backup power only momentarily deenergizes the system.

Note: Rescue must be effected quickly. After five minutes, the chances of saving the individual greatly decrease.

- As an extra precaution, and only after the electricity has been turned off, use a stick, rope, leather belt, coat, blanket, or any other dry, nonconductor of electricity to separate the victim from the electrical circuit.

> **Caution:** Do not take hold of the victim with your bare hand.

b. Call for assistance.

- Others in the area may be more knowledgeable than you about treating the victim.
- Another person can call for professional medical help while you administer first aid.

c. Check the victim's breathing and heartbeat.

Note: Time is life at this point!

- If a pulse is detectable but breathing has stopped, administer mouth-to-mouth resuscitation until the victim resumes breathing or medical help arrives.
- If the heartbeat has stopped, administer cardiopulmonary resuscitation (CPR), until the victim's heartbeat resumes or medical help arrives—but only if you have been trained in the proper technique.

> **Caution:** CPR can sometime cause more harm than good to a victim unless the person administering the first aid has been trained in the proper procedure.

- If both the heartbeat and breathing have stopped, alternate between cardiopulmonary resuscitation and mouth-to-mouth resuscitation, but again, only if you have been trained in this technique.

d. Administer first aid for burns

- Cover your mouth and nose with a clean handkerchief to prevent breathing germs on the victim.
- Locate and treat both the entrance and exit burns.
- Cool burns with a damp compress and then cover with a dry, sterile dressing.

Caution: Do not attempt any other treatment of burns.

e. Administer first aid for traumatic shock.

- Lay victim down.
- Elevate victim's legs slightly above head level.
- Cover to prevent loss of body heat.

f. Continue treatment, but only within your ability, until medical help arrives.

Student Supplement 1—Lockout/Tagout Procedures for Electrical Equipment

Lockout/Tagout procedures are used to prevent electric shock or other injuries resulting from either direct or indirect contact with fixed electrical equipment, when:

a. Working on or near equipment or circuits which are, or may be energized

b. Required to remove or bypass a guard or other safety device

c. Required to place any part of your body into an area on a machine or piece of equipment, where work is actually performed upon the material being processed

   Note: Fixed equipment is equipment fastened in place or connected by hard wiring methods. Lockout/tagout does not apply to cord and plug connected equipment, if the equipment can be "unplugged' and the plug is under the exclusive control of the person performing the work.

"Live" parts shall be deenergized before the employee works on or near them, unless the employer can demonstrate that deenergizing introduces increased hazards or is infeasible due to equipment design or operational limitations. Live parts that operate at less than 50 volts to ground, need not be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

Procedures for deenergizing equipment::

a. Disconnect the circuits and equipment from all electric energy sources.

   Note: Control circuit devices, such as push buttons, selector switches, and interlocks, may not be used as the sole means for deenergizing circuits or equipment. Interlocks for electric equipment may not be sued as a substitute for lockout and tagging procedures

b. Release stored electric energy if it might endanger life.

c. If stored non-electric energy could reenergize electric circuit parts, they shall be blocked or relieved so that the device could not accidentally energize the circuit parts.

If an employee is exposed to parts of fixed electrical equipment or circuits which have been deenergized, the circuits energizing the parts shall be locked out or tagged, or both.

A lock and tag shall be placed on each disconnecting means used to deeenergize circuits and equipment on which work is to be performed.

a. The lock shall be attached so as to prevent persons from operating the disconnecting means unless they resort to undue force or the use of tools.

b. Each tag shall contain a statement prohibiting unauthorized operation of the disconnecting means and removal of the tag.

A tag may be used without a lock if the employer can demonstrate that tagging procedures will provide a level of safety equivalent to that obtained by the use of a lock and:

a. The tag is supplemented by at least one additional safety measure that provides a level of safety equivalent to that obtained by use of a lock. Examples of additional safety measures include the removal of an isolating circuit element, blocking of a controlling switch, or opening of an extra disconnecting device.

A lock may be placed without a tag only under the following conditions:

a. Only one circuit or piece of equipment is deenergized and

b. The lockout period does not extend beyond the work shift, and

c. Employees exposed to the hazards associated with reenergizing the circuit or equipment are familiar with this procedure.

Each lock and tag shall be removed by the employee who applied it or under his or her direct supervision. However, if this employee is absent from the workplace, then the lock or tag may be removed by a qualified person designated to perform this task.

Unit Contents

Student Components

Student Page

Learning Activities Sheet 4–3

Objective Sheet 4–7

Information Sheet 4–9

* Assignment Sheets

1—Add Whole Numbers 39
2—Subtract Whole numbers 43
3—Multiply Whole Numbers 47
4—Divide Whole Numbers 51
5—Reduce Fractions to Lowest Terms 55
6—Convert Fractions and Mixed Numbers 57
7—Add Fractions 59
8—Subtract Fractions 63
9—Multiply Fractions 69
10—Add Decimal Numbers 71
11—Subtract Decimal Numbers 75
12—Multiply Decimal Numbers 79
13—Divide Decimal Numbers 83
14—Convert Fractions and Percentages 87
15—Solve Percentage Problems 91
16—Calculate Area of Geometric Figures 95

* Assignment Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ________________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment.

☐ 4. **Stop** Ask instructor to evaluate the completed focus assignment. After work has been evaluated, follow instructor's recommendations.

☐ 5. **Study** Information Sheet, Objectives 1 through 4.

☐ 6. **Do** Assignment Sheet 1, "Add Whole Numbers."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat steps 5 and 6.

☐ 8. **Study** Information Sheet, Objective 5.

☐ 9. **Do** Assignment Sheet 2, "Subtract Whole Numbers."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat steps 8 and 9.

☐ 11. **Study** Information Sheet, Objective 6.

☐ 12. **Do** Assignment Sheet 3, "Multiply Whole Numbers."

☐ 13. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, repeat steps 11 and 12.

☐ 14. **Study** Information Sheet, Objective 7.

☐ 15.	**Do**	Assignment Sheet 4, "Divide Whole Numbers."
☐ 16.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat steps 14 and 15.
☐ 17.	**Study**	Information Sheet, Objectives 8 and 9.
☐ 18.	**Do**	Assignment Sheet 5, "Reduce Fractions to Lowest Terms."
☐ 19.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, repeat steps 17 and 18.
☐ 20.	**Study**	Information Sheet, Objective 10.
☐ 21.	**Do**	Assignment Sheet 6, "Convert Fractions and Mixed Numbers."
☐ 22.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 23. If the evaluation is not satisfactory, repeat steps 20 and 21.
☐ 23.	**Study**	Information Sheet, Objective 11.
☐ 24.	**Do**	Assignment Sheet 7, "Add Fractions."
☐ 25.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 26. If the evaluation is not satisfactory, repeat steps 23 and 24.
☐ 26.	**Study**	Information Sheet, Objective 12.
☐ 27.	**Do**	Assignment Sheet 8, "Subtract Fractions."
☐ 28.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 29. If the evaluation is not satisfactory, repeat steps 26 and 27.
☐ 29.	**Study**	Information Sheet, Objective 13.

☐ 30. **Do** Assignment Sheet 9, "Multiply Fractions."

☐ 31. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 32. If the evaluation is not satisfactory, repeat steps 29 and 30.

☐ 32. **Study** Information Sheet, Objectives 14 and 15.

☐ 33. **Do** Assignment Sheet 10, "Add Decimal Numbers."

☐ 34. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 35. If the evaluation is not satisfactory, repeat steps 32 and 33.

☐ 35. **Study** Information Sheet, Objective 16.

☐ 36. **Do** Assignment Sheet 11, "Subtract Decimal Numbers."

☐ 37. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 38. If the evaluation is not satisfactory, repeat steps 35 and 36.

☐ 38. **Study** Information Sheet, Objective 17.

☐ 39. **Do** Assignment Sheet 12, "Multiply Decimal Numbers."

☐ 40. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 41. If the evaluation is not satisfactory, repeat steps 38 and 39.

☐ 41. **Study** Information Sheet, Objective 18.

☐ 42. **Do** Assignment Sheet 13, "Divide Decimal Numbers."

☐ 43. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 44. If the evaluation is not satisfactory, repeat steps 41 and 42.

☐ 44. **Study** Information Sheet, Objective 19.

Learning Activities Sheet

☐ 45. **Do** Assignment Sheet 14, "Convert Fractions and Percentages."

☐ 46. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 47. If the evaluation is not satisfactory, repeat steps 44 and 45.

☐ 47. **Study** Information Sheet, Objective 20.

☐ 48. **Do** Assignment Sheet 15, "Solve Percentage Problems."

☐ 49. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 50. If the evaluation is not satisfactory, repeat steps 47 and 48.

☐ 50. **Study** Information Sheet, Objectives 21 through 26.

☐ 51. **Do** Assignment Sheet 16, "Calculate Area of Geometric Figures."

☐ 52. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 53. If the evaluation is not satisfactory, repeat steps 50 and 51.

☐ 53. **Check** With instructor for any additional assignments to be completed.

☐ 54. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 55. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to solve basic math problems and read English and metric rules. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms associated with math and measuring to their correct definitions.
2. Match symbols used in math problems with their names.
3. Label the place values of a whole number.
4. Add whole numbers to solve problems.
5. Subtract whole numbers to solve problems.
6. Multiply whole numbers to solve problems.
7. Divide whole numbers to solve problems.
8. Distinguish among types of fractions.
9. Reduce fractions to lowest terms.
10. Convert fractions and mixed numbers.
11. Add fractions to solve problems.
12. Subtract fractions to solve problems.
13. Multiply fractions to solve problems.
14. Label place values in a decimal number.
15. Add decimal numbers to solve problems.
16. Subtract decimal numbers to solve problems.
17. Multiply decimal numbers to solve problems.
18. Divide decimals to solve problems.
19. Convert decimal fractions to common fractions.
20. Solve percentage problems.

Objective Sheet

21. Match terms used in geometry with their definitions.
22. Match types of geometric figures with their descriptions.
23. Match units of measure with their equivalents.
24. Calculate the area of geometric figures.
25. Match metric prefixes with their values.
26. Solve problems about English-Metric conversion charts.
27. Add whole numbers. (Assignment Sheet 1)
28. Subtract whole numbers. (Assignment Sheet 2)
29. Multiply whole numbers. (Assignment Sheet 3)
30. Divide whole numbers. (Assignment Sheet 4)
31. Reduce fractions to lowest terms. (Assignment Sheet 5)
32. Convert fractions and mixed numbers. (Assignment Sheet 6)
33. Add fractions. (Assignment Sheet 7)
34. Subtract fractions. (Assignment Sheet 8)
35. Multiply fractions. (Assignment Sheet 9)
36. Add decimal numbers. (Assignment Sheet 10)
37. Subtract decimal numbers. (Assignment Sheet 11)
38. Multiply decimal numbers. (Assignment Sheet 12)
39. Divide decimal numbers. (Assignment Sheet 13)
40. Convert fractions and percentages. (Assignment Sheet 14)
41. Solve percentage problems. (Assignment Sheet 15)
42. Calculate area of geometric figures. (Assignment Sheet 16)

Information Sheet

Objective 1

Terms and definitions associated with math and measuring

a. **Whole number (integer)**—Any of the natural numbers, both positive and negative, that represents a complete item

Example: 25 is a whole number as apposed to 3/4, a fraction or part of a whole.

b. **Digit**—Any one of the ten symbols, 0 to 9, by which all numbers can be expressed

c. **Fraction**—Part of a whole; represents one or more equal parts of a unit

Examples:

Figure 1

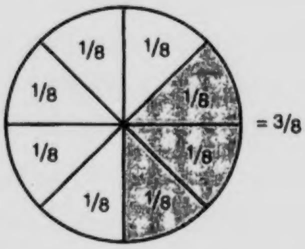
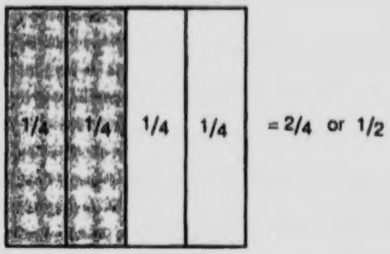


Figure 2



d. **Decimal**—Fraction with an unwritten denominator of 10 or some power of 10; indicated with a point before the number

Examples: 0.1 = 1/10 0.06 = 6/100 0.003 = 3/1000

e. **Addition**—Process of totaling two or more numbers to find another number called a sum

Examples: 3 + 5 + 9 = 17

f. **Subtraction**—Opposite operation of addition

Examples: 8 – 4 = 4 as apposed to 4 + 4 = 8

g. **Multiplication**—Abbreviated process of adding a number to itself a specified number of times

Examples: 6 x 3 = 18 as apposed to 6 + 6 + 6 = 18

h. **Division**—Opposite operation of multiplication

Example: 16 ÷ 2 = 8 as apposed to 8 x 2 = 16

i. **Percent**—One part in a hundred; reckoned on the basis of a whole divided into one hundred parts

j. **Ratio**—Relationship in quantity, amount, or size between two or more things

k. **Proportional**—Being relatively equal in size or quantity

Example: 1:1:3 = 0.5:0.5:1.5

l. **Meter**—Metric unit used to measure length

m. **Liter**—Metric unit used to measure capacity

Objective 2

Interpretations of symbols used in math problems

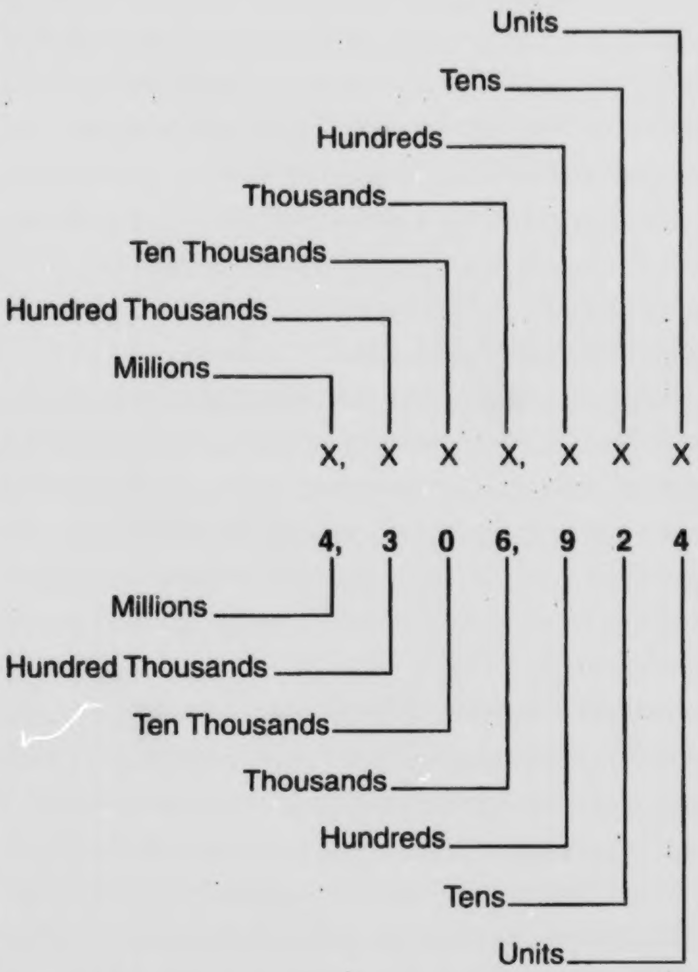
Plus sign (addition)	+
Minus sign (subtraction)	–
Times sign (multiplication)	X
Division sign	÷
Division frame	$\overline{)\ \ }$
Equal sign	=
Decimal point	.
Percent symbol	%
Ratio symbol	:
Pi sign	π

Objective 3

Place values of whole number

Note: The position of a digit in a number shows how much that digit is worth. These positions are called *place values.*

Example:


Units
Tens
Hundreds
Thousands
Ten Thousands
Hundred Thousands
Millions
X, X X X, X X X
4, 3 0 6, 9 2 4
Millions
Hundred Thousands
Ten Thousands
Thousands
Hundreds
Tens
Units

Note: The number in this example is four million, three hundred six thousand, nine hundred twenty-four.

Objective 4

Adding whole numbers

a. Set up problem by writing units under units, tens under tens, and so on.

Example: Add whole number 1632, 17, 550.

$$\begin{array}{r} 1632 \\ 17 \\ \underline{+\ 550} \end{array}$$

b. Add each column separately, beginning at top of units column.

Example:

$$\begin{array}{r} 1632 \\ 17 \\ \underline{+\ 550} \\ 9 \end{array} \qquad \begin{array}{r} 1632 \\ 17 \\ \underline{+\ 550} \\ 99 \end{array}$$

c. If the sum of any column is two or more digits, write the units digit in your answer and carry the remaining digit(s) to the top of next column to the left.

Example:

$$\begin{array}{lr} & 1632 \\ & 17 \\ \text{Write units} & \underline{+\ 550} \\ \text{digit} \longrightarrow & 199 \end{array} \qquad \begin{array}{rl} 1 & \longleftarrow \text{Carry remaining digit.} \\ 1632 & \\ 17 & \\ \underline{+\ 550} & \\ 199 & \end{array}$$

d. Add any carried digit(s) above the column with that column.

Example:

$$\begin{array}{ll} 1 & \text{Carried Digit} \\ 1632 & \\ \quad 17 & \\ \underline{+\ 550} & \\ 2199 & \end{array}$$

Objective 5

Subtracting whole numbers

a. Set up problem by writing units under units, tens under tens, and so on.

Note: Top number in the problem (original number is almost always larger than the bottom number (subtracted number).

Example: Subtract 91 from 123.

$$\begin{array}{rl} 123 & \text{Original Number} \\ \underline{-\ 91} & \text{Subtracted Number} \end{array}$$

b. Subtract each column separately, beginning at bottom of units column.

Example:

$$\begin{array}{r} 123 \\ \underline{-\ 91} \\ 2 \end{array}\uparrow$$

c. If a digit in the subtracted number is larger than the digit above it, "borrow" 1 from the top digit in the next column to the left, decreasing that digit by one and increasing the digit being subtracted by ten.

Example:

$$\begin{array}{r} 123 \\ \underline{-\ 91} \\ 32 \end{array}$$

d. If there is nothing to borrow in the next column (column contains a zero), first borrow for that column for its next left column.

Example:

$$\begin{array}{r} 906 \\ \underline{-\ 318} \\ \end{array} \qquad \begin{array}{r} 906 \\ \underline{-\ 318} \\ 8 \end{array} \qquad \begin{array}{r} 906 \\ \underline{-\ 318} \\ 88 \end{array} \qquad \begin{array}{r} 906 \\ \underline{-\ 318} \\ 588 \end{array}$$

e. Check your subtraction by adding your answer to the subtracted number.

Example: Problem — Check

$$\begin{array}{rcl} 271 & & \text{Original Number} \\ \underline{-\ 164} & \uparrow & \text{Subtracted Number} \\ 107 & & \text{Answer} \end{array} \qquad \begin{array}{rl} 271 & \text{Original Number} \\ -164 & \\ \underline{+107} & \\ 271 & \text{Check Answer} \end{array}$$

Note:If you have solved the problem correctly, your check answer should be the same as the original number.

Objective 6

Multiplying whole numbers

a. Set up problem by writing larger number (original number) above the smaller number (multiplier), writing units under units, tens under tens, and so on.

Note: You will get the correct answer (product) no matter which number is placed above the other, but the faster method places the larger above the smaller.

Example: Multiply the numbers 53 and 4.

$$\begin{array}{rl} 53 & \text{Original Number} \\ \underline{\times\ 4} & \text{Multiplier} \end{array}$$

b. If the multiplier contains only one digit, multiply each digit in the original number by it, working from right to left.

- Multiply units digit in original number by multiplier.
- Write answer units digit and insert necessary carry digit above next left column in original number as required.

Example:

$$\begin{array}{r} 1 \\ 53 \\ \uparrow \\ \underline{\times 4} \\ 2 \end{array}$$

- Multiply tens digit by multiplier and add carried digit as required.

Example:

$$\begin{array}{r} 1 \\ 53 \\ \nwarrow \\ \underline{\times 4} \\ 212 \end{array}$$

c. If the multiplier contains more than one digit, find partial products.

- Multiply each digit in original number by each digit in multiplier, moving from right to left.
- Align partial products so that right-hand digit of each is directly under its corresponding digit in the multiplier.

Example: Multiply the numbers 174 x 42.

$$\begin{array}{rrrrrr}
 & 1 & & 1 & 1 & 2 \\
174 & 174 & 174 & 174 & 174 & 174 \\
\uparrow & \nwarrow & \nwarrow & \nearrow & \uparrow & \nwarrow \\
\underline{\times 42} & \underline{\times 42} & \underline{\times 42} & \underline{\times 42} & \underline{\times 42} & \underline{\times 42} \\
8 & 48 & 348 & 348 & 348 & 348 \\
 & & & 6 & 96 & 696 \\
 & & \uparrow & & & \uparrow
\end{array}$$

First Partial Product

Second Partial Product

d. Add the partial products.

Example:
174
x 42
348
+ 696
7308 Answer (Product)

Objective 7

Dividing whole numbers

a. Set up problem by writing original number (number to be divided) inside a division frame, and by writing divisor (number you are dividing by) outside frame.

Example: How many times will 34 go into 3347?

Divisor 34)3347 Original Number

b. Determine how many times the divisor will go into the first digit of the original number. If it will not, write a zero in the answer space directly above the first digit. Then determine how many times the divisor will go into the first two numbers of the original number.

Note: Continue trying to divide the original number by the divisor until a set of digits can be divided. Remember to write a zero each time the set of digits cannot be divided.

Example:
0
34)3347 34 goes into 3 zero times.

00
34)3347 34 goes into 33 zero times.

009
34)3347 34 goes into 334 nine times.

c. Multiply the divisor by the answer (digit above frame); write this answer under the digit(s) that divisor went into, and subtract.

Example:
34 Multiply divisor (34) by
x 9 answer (9).
306

009
34)3347
– 306
28

d. Bring down next unused digit from original number, and place it to the right of the subtracted difference (remainder)—even if the remainder is zero.

Example:

$$\begin{array}{r} 009 \\ 34\overline{)3347} \\ \underline{306\downarrow} \\ 287 \end{array}$$

e. Determine how many times the divisor will go into this new number; write your answer in the answer space above the digit that was brought down.

Example

$$\begin{array}{r} 0098 \\ 34\overline{)3347} \\ \underline{306} \\ 287 \end{array}$$

f. Multiply the divisor by the last digit you wrote in the answer; write this product under the digits that divisor went into, and subtract.

Example:

$$\begin{array}{r} 34 \\ \underline{\times 8} \\ 272 \end{array}$$

Multiply divisor (34) by answer (8).

$$\begin{array}{r} 0098 \\ 34\overline{)3347} \\ \underline{306} \\ 287 \\ \underline{-272} \\ 15 \end{array}$$

Write product under 287, the digits that divisor went into, and subtract.

g. Continue this process until all numbers in original number are used.

h. Write any remaining subtracted difference as a remainder.

Example:

$$\begin{array}{rl} 0098 & \\ 34\overline{)3347} & \\ \underline{306} & \\ 287 & \\ \underline{-272} & \\ 15 & \text{Remainder} \end{array}$$

i. Check your answer by multiplying your answer times the divisor and adding the remainder to this number.

Note: If you have solved the problem correctly, your check answer should be the same as your original number.

Example		
	98	Answer
	x 34	Divisor
	392	
	294	
	3332	
	+ 15	Remainder
	3347	Check Answer (Same as Original Number)

Objective 8

Distinguishing among types of fractions

a. **Proper**—Top number of fraction (numerator) is smaller than bottom number of fraction (denominator).

Examples: $\frac{7}{8}$ Numerator
Denominator

b. **Improper**—Top number of fraction (numerator) is larger than bottom number of fraction (denominator,) or the same as the bottom number.

Examples: $\frac{9}{8}$ $\frac{16}{16}$

c. **Mixed numbers**—Contain a whole number and a proper fraction.

Examples: 9 $^{1}/_{2}$, 1 $^{7}/_{8}$, 4 $^{3}/_{4}$

Objective 9

Reducing fractions to lowest terms—Divide the numerator and denominator by the largest whole number that will go into each evenly.

Examples: Reduce $^{4}/_{16}$ to its lowest terms.

$$\frac{4}{16} \quad \frac{4 \div 4}{16 \div 4} \quad \frac{1}{4}$$

Note: The fraction $^{1}/_{4}$ is reduced to its lowest term because the numerator (1) and the denominator (4) cannot be divided by the same number.

Information Sheet

Objective 10

Converting mixed numbers and improper fractions

a. Converting mixed numbers to improper fractions

- Multiply the whole number by the denominator of the fraction.

  Example: Convert $4\,{}^{3}/_{8}$ to an improper fraction.

  $8 \times 4 = 32$

- Add your answer to the numerator.

  Example: $32 + 3 = 35$

- Place this sum over the original denominator.

  Example: $\frac{35}{8}$ Improper Fraction

b. Converting improper fractions to mixed numbers

- Divide the numerator by the denominator.

  Example: Convert ${}^{18}/_{15}$ to a mixed number.

  $$\begin{array}{r} 01 \\ 15\overline{)18} \\ \underline{15} \\ 3 \end{array} \quad \text{Remainder}$$

- Place the remainder over the denominator.

  Example: $\frac{3}{15}$ Remainder / Denominator

- Reduce this fraction if necessary.

  Example: $\frac{3}{15} = \frac{3 \div 3}{15 \div 3} = \frac{1}{5}$

- Add the reduced fraction to the whole number obtained by dividing the numerator by the denominator.

  Example: $1 + \frac{1}{5} = 1\frac{1}{5}$ Mixed Number

Objective 11

Adding fractions

a. Like fractions

Note: Like fractions are those having the same, or common, denominators.

Example: $^1/_4$ and $^2/_4$, $^5/_8$ and $^5/_8$, and $^1/_{16}$ and $^3/_{16}$

- Add the numerators.
- Place sum of numerators over common denominator.
- Convert to mixed numbers and reduce as required.

Example: Add $^1/_4$ and $^2/_4$.

$$\frac{1}{4} + \frac{2}{4} = \frac{1+2}{4} = \frac{3}{4}$$

Example: Add $^5/_8$ and $^5/_8$.

$$\frac{5}{8} + \frac{5}{8} = \frac{5+5}{8} = \frac{10}{8} = 10 \div 8 = 1\frac{2}{8} = 1\frac{1}{4}$$

Example: Add $^1/_{16}$ and $^3/_{16}$.

$$\frac{1}{16} + \frac{3}{16} = \frac{1+3}{16} = \frac{4}{16} = \frac{4 \div 4}{16 \div 4} = \frac{1}{4}$$

b. Unlike fractions

Examples: $^{11}/_{12}$ and $^3/_9$, $^1/_8$ and $^3/_4$

- Change to like fractions.
  - — Find the lowest number into which each denominator can be divided evenly (lowest common denominator).

598

— Multiply the numerators and denominators of each fraction by the number of times its denominator can be divided into the lowest common denominator.

Example: Add $^{11}/_{12}$ and $^{3}/_{9}$.

36 is lowest number into which both 12 and 9 can be divided evenly.

$36 \div 12 = 3$

$36 \div 9 = 4$

$$\frac{11}{12} = \frac{11 \times 3}{12 \times 3} = \frac{33}{36}$$

$$\frac{3}{9} = \frac{3 \times 4}{9 \times 4} = \frac{12}{36}$$

Example: Add $^{1}/_{8}$ and $^{3}/_{4}$.

8 is lowest number into which both 8 and 4 can be divided evenly.

$8 \div 8 = 1$

$8 \div 4 = 2$

$^{1}/_{8}$ remains as $^{1}/_{8}$ because 8 is the common denominator.

$$\frac{3}{4} = \frac{3 \times 2}{4 \times 2} = \frac{6}{8}$$

- Add like fractions and reduce or convert to mixed numbers as required.

Example: Add $^{11}/_{12}$ and $^{3}/_{9}$

$\frac{11}{12} = \frac{33}{36}$ and $\frac{3}{9} = \frac{12}{36}$

$$\frac{33}{36} + \frac{12}{36} = \frac{33 + 12}{36} = \frac{45}{36} = \frac{5}{4} = 1\frac{1}{4}$$

Example: Add $^{1}/_{8}$ and $^{3}/_{4}$

$\frac{1}{8}$ remains $\frac{1}{8}$ and $\frac{3}{4} = \frac{6}{8}$

$$\frac{1}{8} + \frac{6}{8} = \frac{1 + 6}{8} = \frac{7}{8}$$

c. Mixed numbers

- Add whole numbers.
- Add fractions, first finding common denominators if necessary, and reduce or convert to mixed numbers as necessary.
- Add the sums of steps 1 and 2.

Example: Add 3 $^1/_8$ and 7 $^3/_8$

Add whole numbers:

$3 + 7 = 10$

Add fractions and reduce:

$$\frac{1}{8} + \frac{3}{8} = \frac{1+3}{8} = \frac{4}{8} = \frac{1}{2}$$

Add the sums of steps 1 and 2:

$$10 + \frac{1}{2} = 10\frac{1}{2}$$

Example: Add 4 $^2/_3$ and 1 $^5/_6$

Add whole numbers:

$4 + 1 = 5$

Find common denominator:

$$\frac{2}{3} + \frac{5}{6} = \frac{4}{6} + \frac{5}{6}$$

Add fractions, convert to mixed number, and reduce:

$$\frac{4}{6} + \frac{5}{6} = \frac{9}{6} = 1\frac{3}{6} = 1\frac{1}{2}$$

Add the sums of steps 1 and 2:

$$5 + 1\frac{1}{2} = 6\frac{1}{2}$$

Objective 12

Subtracting fractions

a. Like fractions

- Subtract smaller numerator from lager numerator.

  Example: Subtract $^1/_{16}$ from $^7/_{16}$.

  $7 - 1 = 6$

- Place subtraction answer over common denominator.

  Example: $\frac{6}{16}$

- Reduce to lowest terms as required.

  Example: $\frac{6}{16} = \frac{3}{8}$

b. Unlike fractions

- Change to like fractions.

  Example: Subtract $^1/_2$ from $^3/_4$.

  $^3/_4$ remains the same because 4 is the common denominator.

  $\frac{1}{2} = \frac{1 \times 2}{2 \times 2} = \frac{2}{4}$

- Subtract as for like fractions.

  $\frac{3}{4} - \frac{2}{4} = \frac{3 - 2}{4} = \frac{1}{4}$

- Reduce to lowest terms as required.

c. Mixed numbers

- Convert mixed numbers to like fractions.

  Example: Subtract 3 $^1/_2$ from 5 $^1/_8$.

  $5\frac{1}{8} - 3\frac{1}{2} =$

  $5\frac{1}{8} - 3\frac{4}{8} =$

- Borrow a one from the original whole number if needed, convert the one to a like fraction, and add it to the smaller fraction.

  Note: This step is needed only if the like fraction in the original number is smaller than the like fraction in the subtracted number.

  Example:

  $$5\frac{1}{8} - 3\frac{4}{8} = (4\frac{8}{8} + \frac{1}{8}) - 3\frac{4}{8}$$

  $$= 4\frac{9}{8} - 3\frac{4}{8}$$

- Subtract whole number from whole number and like fraction from like fraction.

  Example: $4\frac{9}{8} - 3\frac{4}{8} = 1\frac{5}{8}$

Objective 13

Multiplying fractions

a. Convert mixed numbers to improper fractions if necessary.

b. Multiply numerators by numerators and denominators by denominators.

c. Write the product of the numerators over the product of the denominators.

d. Convert improper fractions to mixed numbers and reduce as required.

Example: Multiply $^1/_2$ by $^3/_4$.

$$\frac{1}{2} \times \frac{3}{4} = \frac{1 \times 3}{2 \times 4} = \frac{3}{8}$$

Example: Multiply 1 $^1/_4$ by $^1/_2$.

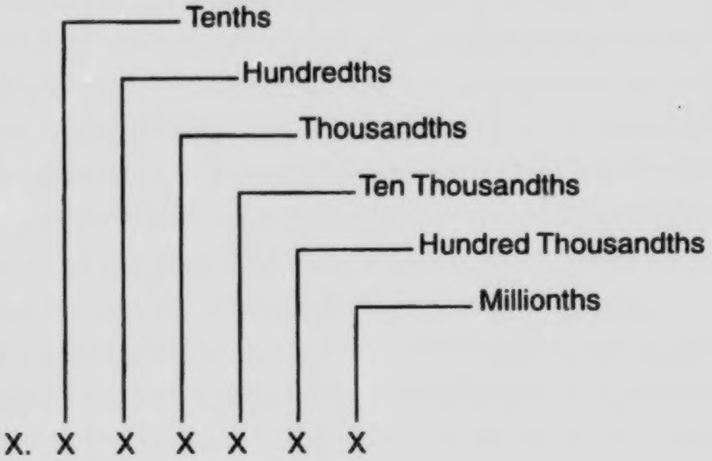
$1\frac{1}{4} \times \frac{5}{4}$ Convert to improper fraction.

$$\frac{5}{4} \times \frac{1}{2} = \frac{5 \times 1}{4 \times 2} = \frac{5}{8}$$

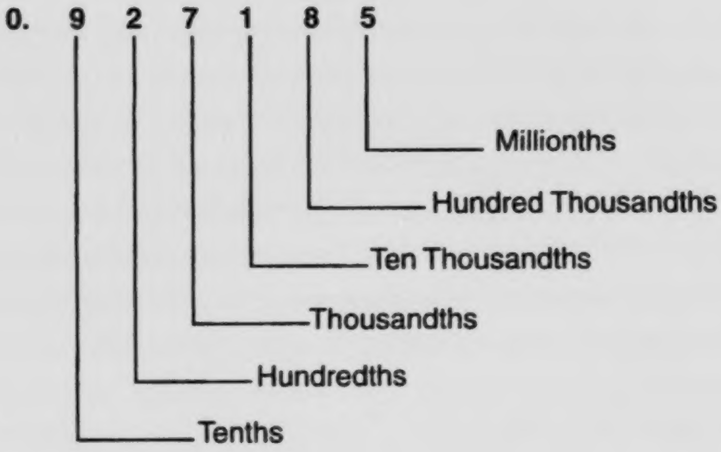
Information Sheet

Objective 14

Place values of decimal numbers


Tenths
Hundredths
Thousandths
Ten Thousandths
Hundred Thousandths
Millionths
X. X X X X X X

Example:


0. 9 2 7 1 8 5
Millionths
Hundred Thousandths
Ten Thousandths
Thousandths
Hundredths
Tenths

Note: The number in the example is read as nine hundred twenty-seven thousandths, one hundred eighty-five millionths.

Objective 15

Adding decimal numbers

a. Set up problem as for addition of whole numbers, aligning decimal points directly under each other.

Note: Zeros may be added to ensure that units line up under units, tens under tens, and so on. Whole numbers have an understood decimal point to the right of the units digit: 7 is 7., 75 is 75., and 754 is 754.

Example: Add 0.857, 2.1, 753, and 370.057.

0.857	000.857
2.1	002.100
753	735.000
+ 370.057	+ 370.057

b. Add each column of numbers as for whole numbers.

c. Locate the decimal point in the answer by placing it directly under the decimal points above.

Example:

000.857	
002.100	
753.000	
+ 370.057	
1126.014	Answer

Objective 16

Subtracting decimal numbers

a. Set up problem as for subtraction of whole numbers, aligning decimal points directly under each other.

Example: Subtract 1.397 from 8.120.

8.120	Original Number
– 1.397	Subtracted Number

b. Subtract each column of numbers as for whole numbers.

c. Locate the decimal point in the answer by placing it directly under the decimal points above.

d. Check your subtraction by adding your answer to the subtracted number.

Note: If you have solved the problem correctly, your check answer should be the same as the original number.

Example:

8.120	Original Number
– 1.397	Subtracted Number
+ 6.723	Answer (Difference)
8.120	Check Answer

Information Sheet

Objective 17

Multiplying decimal numbers

a. Set up problem and multiply as for multiplication of whole numbers.

Note: Do not align the decimal points in columns when setting up multiplication problems for decimal numbers.

Example: Multiply 27.935 by 7.07.

$$\begin{array}{r l} 27.935 & \text{Original Number} \\ \underline{\text{x}\ \ 7.07} & \text{Multiplier} \\ 195545 & \\ \underline{955450\ } & \\ 19750045 & \end{array}$$

b. Add the number of decimal placed to the right of the decimal points in the multiplier and original number.

Example:

$$\begin{array}{r r l} 27.935 & 3 & \text{Decimal Places} \\ \underline{\text{x}\ 7.07} & \underline{+\ 2} & \text{Decimal Places} \\ & 5 & \text{Total Decimal Places} \end{array}$$

c. Locate the decimal point in answer by beginning at far right digit and counting off as many places to the left as the total decimal places found in step B.

Example:

$$\begin{array}{r l} 27.935 & \\ \underline{\text{x}\ \ \ \ 7.07} & \\ 195545 & \\ \underline{1955450\ } & \\ 197.50045 & \text{5 Decimal Places} \end{array}$$

Objective 18

Dividing decimal numbers

a. Set up problem as for division of whole numbers.

Example: Divide 0.25 by 0.005.

Divisor $0.005\overline{)0.25}$ Original Number

b. Move the decimal point in the divisor to the right of the far right digit in the divisor.

Example: $0.005.\overline{)0.25}$

c. Move the decimal point in the original number to the right by the same number of decimal places that you moved the decimal point in the divisor, adding zeros to the original number if necessary.

Example: $0.005.\overline{)0.250.}$

Note: If you are dividing a decimal number into a whole number, remember that whole numbers have an understood decimal point to the right of the units digit.

Example: 0.03 9 becomes 0.03. 9.00.

d. Place a decimal pint in the answer space directly above the repositioned decimal point in the original number.

Example: $0.005.\overline{)0.250\overset{\cdot}{.}}$

e. Divide as for whole numbers.

Example:
$$\begin{array}{r} 50. \\ 0005.\overline{)0250.} \\ \underline{025} \\ 00 \end{array}$$

f. Check your division by multiplying the original divisor (before decimal point was moved) by your answer and adding any remainder to this number.

Note: If you have solved the problem correctly, your check answer should be the same as the original number.

Example:	0.005	Divisor
	x 50	Answer
	0.250	Check Answer (Same as Original Number)

Objective 19

Converting Fractions

a. Converting decimal fractions to common fractions

- Remove the decimal point.
- Place number over its respective denominator (10's, 100's, 1000's).
- Cancel zeros when possible.

606

- Reduce to lowest terms.

  Example: Convert .25 to a common fraction

  $$\begin{aligned} .25 &= 25 \\ &= \frac{25}{100} \\ &= \frac{1}{4} \end{aligned}$$

  Example: Convert .520 to a common fraction

  $$\begin{aligned} .520 &= 520 \\ &= \frac{52\cancel{0}}{100\cancel{0}} \\ &= \frac{52}{100} \\ &= \frac{13}{25} \end{aligned}$$

b. Converting common fractions to decimals and percentages

- Fractions to decimals—Divide the numerator by the denominator.

  Example: Convert 5/8 to a decimal.

  $$\begin{array}{ll} \underline{5} & \text{Numerator} \\ 8 & \text{Denominator} \end{array} \qquad \begin{array}{r} 0.625 \\ 8\overline{)5.000} \\ \underline{4\,8} \\ 20 \\ \underline{16} \\ 40 \\ \underline{40} \\ 0 \end{array}$$

- Fractions to percentages—Divide the numerator by the denominator.

  Note: Percent means that a number is a fraction of 100.

  — Convert the fractions to decimals by dividing numerator by denominator.

  — Move the decimal point in the answer two places to the right.

- Place the percent symbol after the number.

Example: Convert $^7/_{33}$ to a percentage.

$\frac{7}{33}$ Numerator / Denominator

```
   0.2121  = 21.21%
33)7.0000
   6 6
     40
     33
      70
      66
       40
       33
        7
```

c. Converting percentages to fractions and decimal numbers

- Percentages to fractions
  - Drop the percent symbol.
  - Place the number over 100.
  - Reduce to lowest terms if necessary.

  Example: Convert 38% to a fraction

  $$38\% = 38$$
  $$= \frac{38}{100}$$
  $$= \frac{19}{50}$$

- Percentages to decimals
  - Drop the percent symbol.
  - Move the decimal point two places to left.

  Example: Convert 74% to a decimal

  $$74\% = 74$$
  $$= 0.74$$

Objective 20

Solving percentage problems

Note: Percentage problems may involve solving for the percent ("16 is what percent of 80?"), the part ("What number is 20% of 80?"), or the whole ("16 is 20% of what number?").

a. Write the unknown as "X".

Note: The unknown may be the percent, the part, or the whole.

Example: 16 is what percent of 80?

16 is X percent of 80.

b. Write the percent (known or unknown) as a fraction with a denominator of 100.

Example: 16 is $\frac{X}{100}$ percent of 80.

c. Write the part and the whole as a fraction, writing the part as the numerator and the whole as the denominator.

Example: $\frac{16}{80}$ $\frac{\text{Part}}{\text{Whole}}$

d. Set up the equation by writing the two fractions with an equal sign between them.

Example: $\frac{X}{100} = \frac{16}{80}$

e. Solve the equation by multiplying the numerator of each fraction by the denominator of the other.

Note: This process is known as *cross multiplying*.

Example: $\frac{X}{100} = \frac{16}{80}$

$80X = 1600$

f. Divide each side of the equation by the multiplier of X.

Example: $80X = 1600$

$X = 20\%$

16 is 20% of 80.

Objective 21

Terms used in geometry

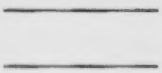
a. **Geometric figure**—Shape formed by straight or curved lines

b. **Perimeter**—Outer limits or boundary

c. **Lineal**—Relating to, consisting of, or resembling a straight line

d. **Parallel**—Line or surface extending in the same direction an equal distance apart and never meeting

Example:



e. **Right angle**—Angle formed by two lines perpendicular to each other; a 90 degree angle

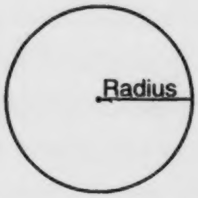
Example:

f. **Perpendicular**—Line or surface at right angle to another line or surface

Example:

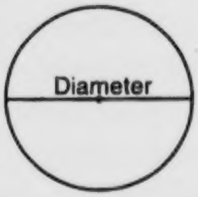
g. **Radius**—Line from the center of a circle to any point on the edge of the circle

Example:



h. **Diameter**—Distance between the outer edges of a circle through its center point

Example:



i. **Circumference**—Distance around the outer edge of a circle

j. **Pi**—Gree letter (π) representing the ratio of a circle's circumference to its diameter; ratio is approximately 3.1416

k. **Area**—Measure of a flat surface; expressed in square units

Example: W x L - Area is square units

l. **Volume**—Space occupied by a body; expressed in cubic units

m. **Cubic unit**—Unit with three equal dimensions including length, width, and height

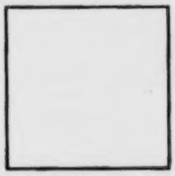
n. **Cubic foot**—Volume of an object that is 1 foot long, 1 foot wide, and 1 foot high

Objective 22

Terms of geometric figures

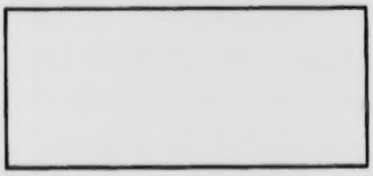
a. **Square**—Figure having four sides of equal length and four right angles

Example:



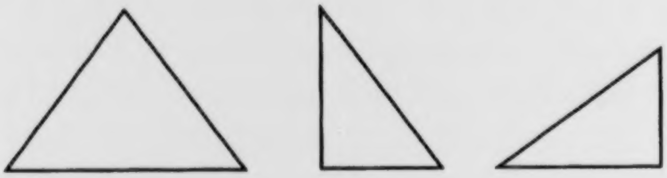
b. **Rectangle**—Figure with two parallel ends of equal length, two parallel sides of equal length, and four right angles

Example:



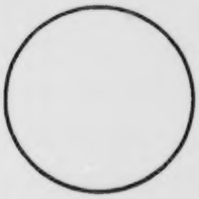
c. **Triangle**—Figure having three sides and three angles

Example:



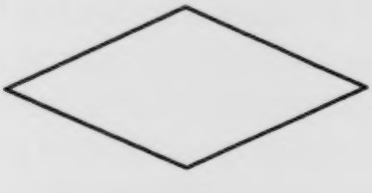
d. **Circle**—Flat, round figure formed by one curved line, all points of which are an equal distance from center point

Example:



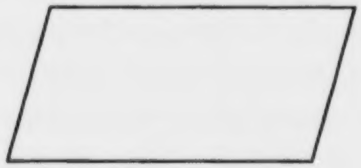
e. **Rhombus**—Figure having no right angles and four sides of equal length

Example:



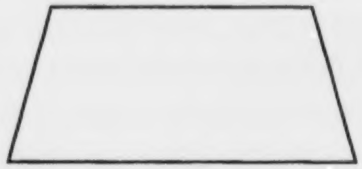
f. **Parallelogram**—Figure such as a square, rectangle, or rhombus with two parallel ends of equal length and two parallel sides of equal length

Example:



g. **Trapezoid**—Figure with only one pair of parallel opposite sides

Example:



Objective 23

Units of measure and their equivalents

a. **Inch (″)**—Equal to one-twelfth of a foot (1/12′) or one thirty-sixth of a yard 1/36 yard)

b. **Foot (′)**—Equal to twelve inches (12″) or one-third of a yard (1/3 yard)

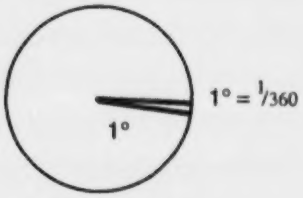
c. **Yard**—Equal to three feet (3′) or thirty-six inches (36″)

d. **Rod**—Equal to sixteen and one-half feet (16 1/2′)

e. **Mile**—Equal to five thousand, two hundred and eighty feet (5280′)

f. **Degree (°)**—Equal to 1/360 of a circle

Example:



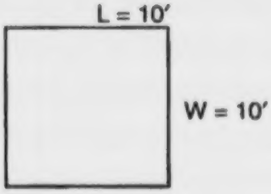
Objective 24

Calculating area of geometric figures

Note: Area is always labeled in square units of measure.

a. **Square**—Use the formula Area = Length x Width or A = LW.

Example:



W = 10′

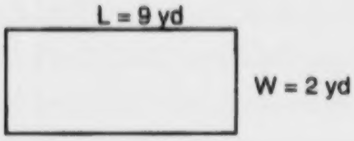
A = LW

= 10 x 10

= 100 square feet

b. **Rectangle**—Use the formula Area = Length x Width or A = LW.

Example:



W = 2yd

A = LW

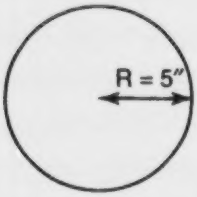
= 9 x 2

= 18 square feet

c. **Circle**—Use the formula Area = πr^2 (radius x radius).

Note: Pi (π) is 3.14, which is the circumference of a circle divided by the diameter of the circle.

Example:



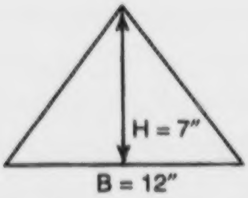
$A = \pi r^2$

= 3.14 x (5 x 5)

= 78.50 square inches

d. **Triangle**—Use the formula Area = $^1/_2$ Base x Height, or A = $^1/_2$ BH.

Example:



$$A = \frac{1}{2}BH$$

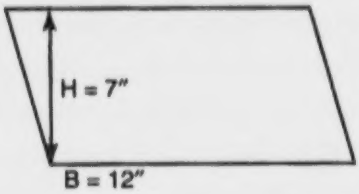
$$=(\frac{1}{2} \times 12) \times 7$$

$$= 6 \times 7$$

$$= 42 \text{ square inches}$$

e. **Parallelogram**—Use the formula Area = Base x Height, or A = BH.

Example:



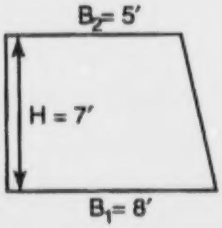
$$A = BH$$

$$= 12 \times 7$$

$$= 84 \text{ square inches}$$

f. **Trapezoid**—Use the formula Area = $^1/_2$ H(B_1 + B_2).

Example:



$$A = \frac{1}{2}H(B_1 + B_2)$$

$$= (\frac{1}{2} \times 7) \times (8 + 5)$$

$$= \frac{7}{2} \times 13$$

$$= \frac{7}{2} \times \frac{13}{1}$$

$$= \frac{91}{2}$$

$$= 45\frac{1}{2} \text{ square feet}$$

Objective 25

Values of prefixes associated with metric measurement

Note: The basic units of measurement in the metric system are the meter (length), liter (capacity), and gram (mass or weight). Other units are named by adding the following prefixes to *meter*, *liter*, or *gram*. Since all measurement units in the metric system are power of 10, metric prefixes make measurements easily understood. A millimeter, for instance, is one thousandth of a meter.

	Prefix	Value
a.	kilo- (k)	one thousand (1000)
b.	hecto- (h)	one hundred (100)
c.	deka- (da)	ten (10)
d.	deci- (d)	one tenth ($^1/_{10}$)
e.	centi- (c)	one hundredth ($^1/_{100}$)
f.	milli- (m)	one thousandth ($^1/_{1000}$)

Objective 26

English-metric conversion charts and how to use them

Note: Because almost all overseas supplies used in American industry are measured on the metric system, the ability to convert metric to English measurement is becoming a common workplace requirement.

a. English-metric conversion charts provide a handy conversion factor for converting metrics to English and English to metrics.

b. To use an English-metric conversion chart, identify the English measurement, the metric form you want to convert it to, and then multiply the English measurement by the proper conversion factor.

Example: If you want to know what 10 inches would be in metric, multiply 10 x 25.4 (the conversion facotr) to get 254 millimeters.

c. To use an English-metric conversion chart, identify the metric measurement, the English form you want to convert it to, and then multiply the metric measurement by the proper conversion factor.

Example: If you want to know what 254 millimeters would be in English, multiply 254 x 0.04 to get 10 inches (the figure is actually 10.1, but it should be rounded off to 10).

Information Sheet

	When You Know	You Can Convert To	When You Multiply By the Conversion Factor
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
AREA	Inches^2	Millimeters^2 (mm^2)	645.2
	Millimeters^2	Inches^2	0.0016
	Inches^2	Centimeters^2 (cm^2)	6.45
	Centimeters^2	Inches^2	0.16
	Foot^2	Meters^2 (m^2)	0.093
	Meters^2	Foot^2	10.76

Unit Contents

Student Components

Student Page

Learning Activities Sheet 5–3

Objective Sheet 5–5

Information Sheet 5–7

* Focus Assignment

List and Price Electrician's Tools 99

* Assignment Sheet

1—Measure Objects Using a Tape Measure 101

* Job Sheets

1—Clean and Lubricate an Adjustable Hand Tool 105
2—Use a Cutting/Crimping Tool 107
3—Adjust Wire Strippers 111
4—Set Up and Use a Hacksaw to Cut Conduit 113
5—Ream and Thread Rigid Conduit 115
6—Bend EMT Conduit 119
7—Use a Knockout Punch 123
8—Use a Hole Saw 127

* Focus Assignment, Assignment Sheet, and Job Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "List and Price Electrician's Tools".

☐ 4. **Stop** Ask instructor to evaluate the completed focus assignment. After work has been evaluated, follow instructor's recommendations.

☐ 5. **Study** Information Sheet, Objectives 1 through 5.

Optional

☐ 6. **View** Videotape entitled "Hand and Power Tool Safety".

☐ 7. **Do** Assignment Sheet 1, "Measure Objects Using a Tape Measure."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, repeat Step 7.

☐ 9. **Study** Information Sheet, Objectives 6 and 7.

☐ 10. **Do** Job Sheets 1 through 8 in succession. See step 11.

☐ 11. **Stop** After completing each job sheet, have instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that Job Sheet and redo the Job Sheet. After satisfactorily completing Job Sheets 1 through 8, continue to step 12.

☐ 12. **Check** With instructor for any additional assignments to be completed.

☐ 13. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 14. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify, use, and care for common hand tools used in the electrical field. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to hand tools with their definitions.
2. Label common hand tools used in the electrical filed.
3. Label electricity-specific hand tools used in the electrical field.
4. Match common hand tools with their uses.
5. Match electricity-specific hand tools with their uses.
6. List factors to consider when purchasing hand tools.
7. Select true statements about rules for care of various hand tools
8. List and price electrician's tools. (Focus Assignment)
9. Measure objects using a tape measure. (Assignment Sheet 1)
10. Clean and lubricate an adjustable hand tool. (Job Sheet 1)
11. Use a cutting/crimping tool. (Job Sheet 2)
12. Adjust wire strippers. (Job Sheet 3)
13. Set up and use a hacksaw to cut conduit. (Job Sheet 4)
14. Ream and thread rigid conduit. (Job Sheet 5)
15. Bend EMT conduit. (Job Sheet 6)
16. Use a knockout punch. (Job Sheet 7)
17. Use a hole saw. (Job Sheet 8)

Information Sheet

Objective 1

Terms and definitions

a. **Arbor**—Shaft or spindle used to hold a revolving cutting tool or the work to be cut

b. **Cable-tie**—Plastic straps with pull-through fasteners for binding together conductors or cables

c. **Chuck**—Device for holding a component of a tool rigid

d. **Circuit box**—Box where electrical connections are made, usually through circuit breakers

e. **Conductor**—Material through which electrons flow easily; used to connect components

f. **Conduit**—Pipe or tube that holds and protects wires or cables

g. **Coupling**—Mechanical device for connecting conduits and cabling

h. **Fuse**—Safety device placed in a circuit; in cases of excessive current, it melts, thus opening the circuit

i. **Heat shrink**—Nonconductive material placed around a conductor for insulation; shrinks when heated

j. **Insulation**—Nonconductive material that prevents leakage of electricity from a conductor and protects against accidental contact

k. **Live circuit**—Circuit with voltage applied

l. **Plasterboard**—Thin board formed of layers of plaster and paper; Sheetrock

m. **Print**—Industrial blueprint; industrial wiring diagram

n. **Snap ring**—Metal ring that fastens around or in a shaft to keep other parts stationary

o. **Spaghetti**—Nonconductive material placed around a conductor for insulation; does not shrink

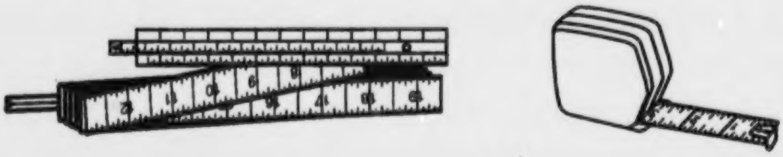
p. **Wire lug**—Metal connector crimped or soldered to a conductor; allows conductor to be fastened with a screw or bolt

Objective 2

Common hand tools used in the electrical field

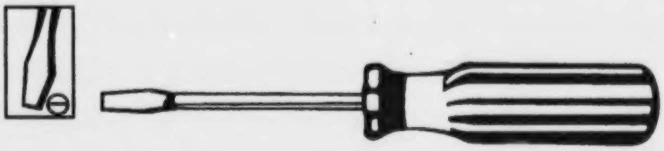
a. Folding rule and tape measure

Figure 1



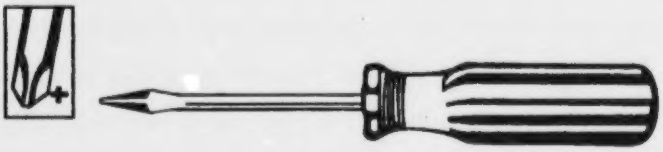
b. Flat-blade screwdriver

Figure 2



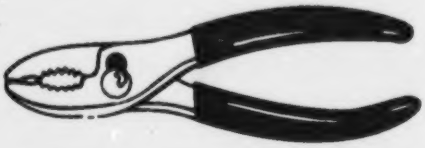
c. Phillips screwdriver

Figure 3



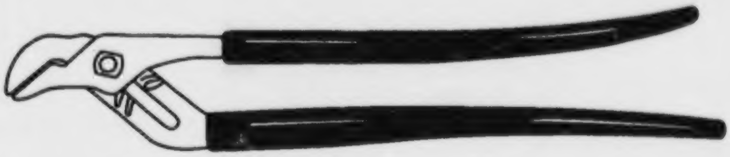
d. Slip-joint pliers

Figure 4



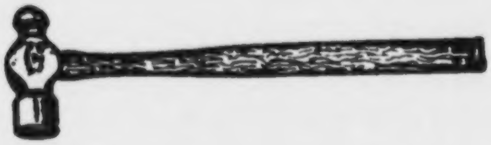
e. Channel-lock wrench

Figure 5



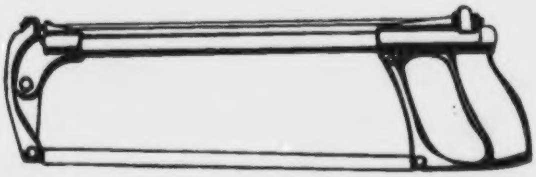
f. Ball peen hammer

Figure 6



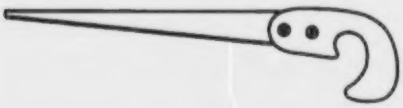
g. Hacksaw

Figure 7



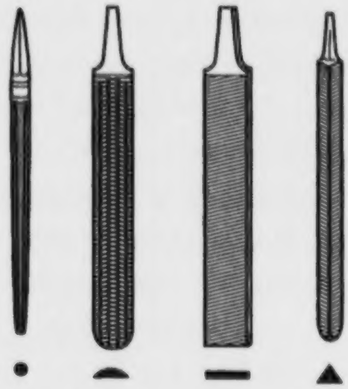
h. Keyhole saw

Figure 8



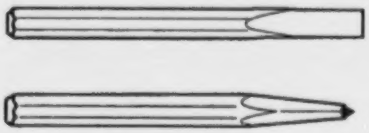
i. File

Figure 9



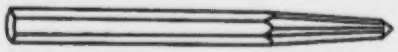
j. Chisels

Figure 10



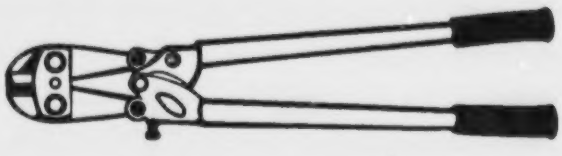
k. Center punch

Figure 11



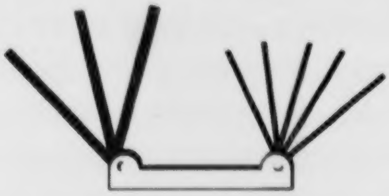
l. Bolt cutter

Figure 12



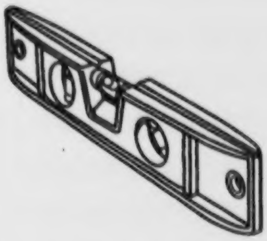
m. Hex key set (Allen wrenches)

Figure 13



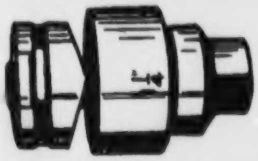
n. Magnetic torpedo level

Figure 14



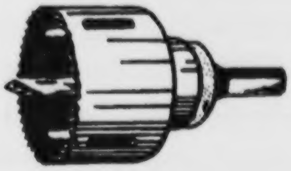
o. Knockout punch

Figure 15



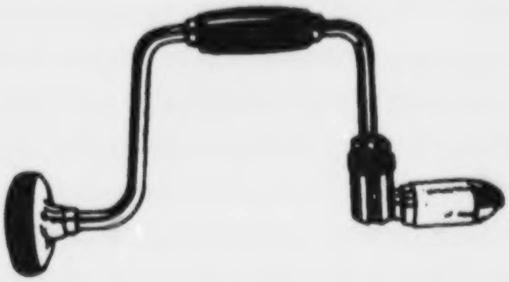
p. Hole saw and arbor

Figure 16



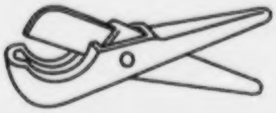
q. Drill brace

Figure 17



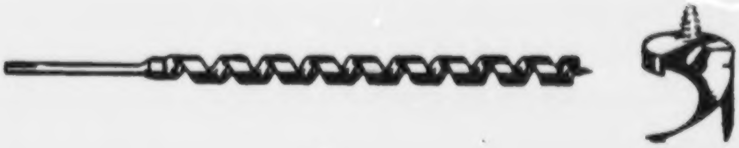
r. PVC cutter

Figure 18



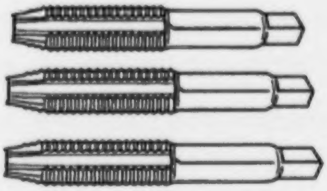
s. Ship auger drill bit

Figure 19



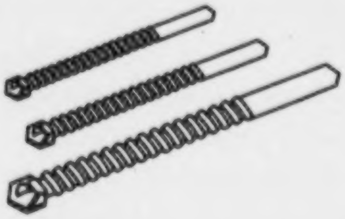
t. Taps

Figure 20



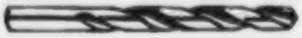
u. Masonry paddle bit

Figure 21



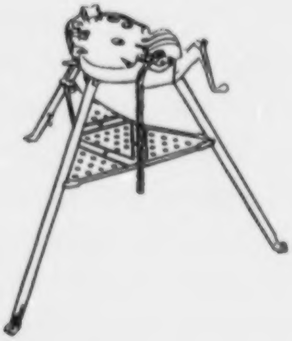
v. Drill bit

Figure 22



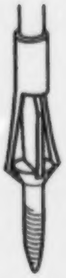
w. Vise stand

Figure 23



x. Screw-holding screwdriver

Figure 24



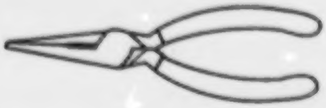
628

Objective 3

Electricity-specific hand tools used in the electrical field

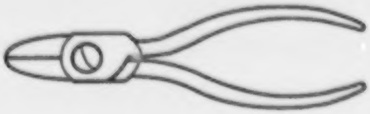
a. Needle-nose pliers

Figure 1



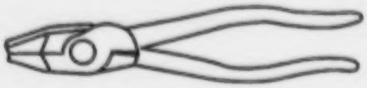
b. Diagonal pliers

Figure 2



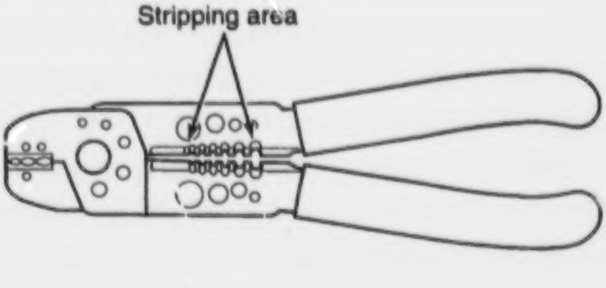
c. Lineman's pliers

Figure 3



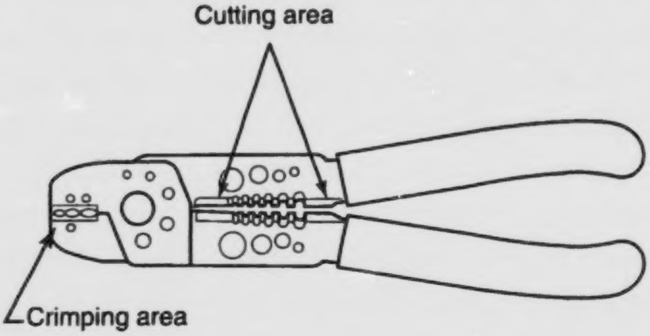
d. Adjustable wire strippers

Figure 4



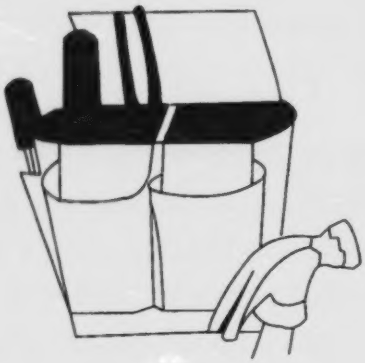
e. Cutting/crimping tool

Figure 5


Cutting area
Crimping area

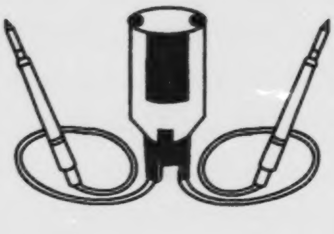
f. Tool pouch

Figure 6



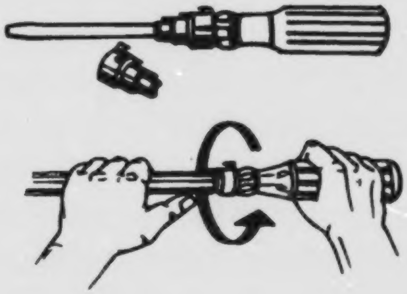
g. Circuit tester

Figure 7



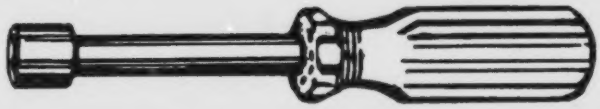
h. Conduit reamer

Figure 8



i. Nut driver

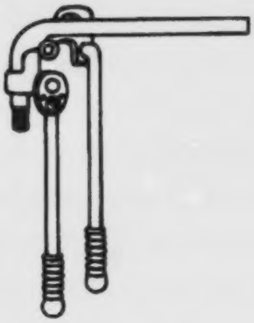
Figure 9



j. Cable bender

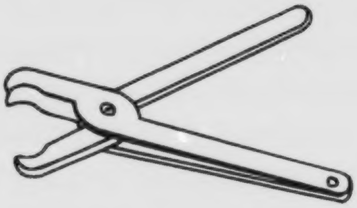
Note: Table 373-6(a) of the *NEC* lists space requirements for cable bending. For specific bending radii, the type of cable must be considered.

Figure 10



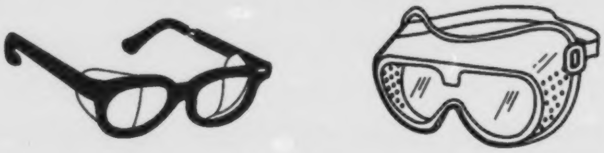
k. Fuse puller

Figure 11



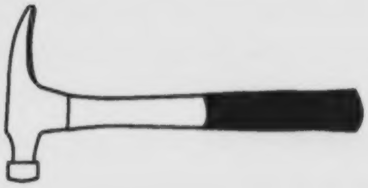
l. Safety glasses and goggles

Figure 12



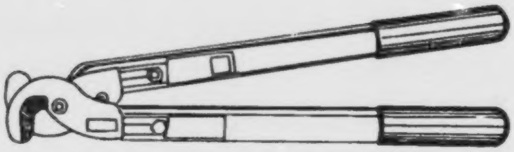
m. Electrician's hammer

Figure 13



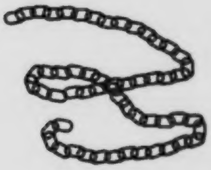
n. Cable cutter

Figure 14



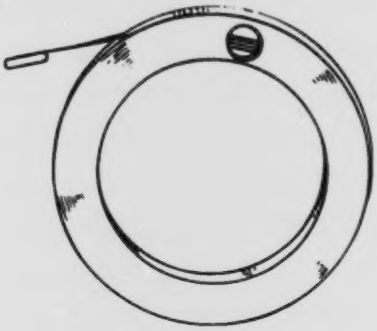
o. Drop chain

Figure 15



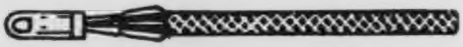
p. Steel fish tape and reel

Figure 16



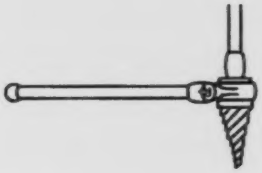
q. Pulling grip-sleeve

Figure 17



r. Pipe reamer

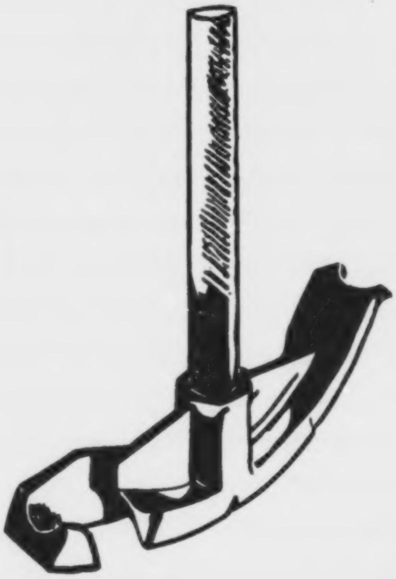
Figure 18



633

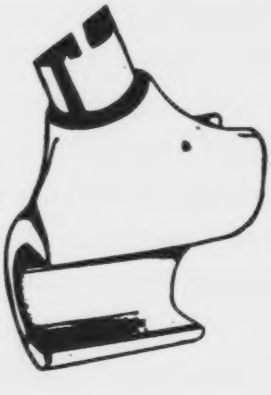
s. Combination conduit/EMT bender

Figure 19



t. Hickey bender

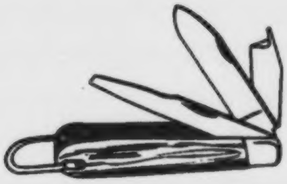
Figure 20



u. Electrician's knife

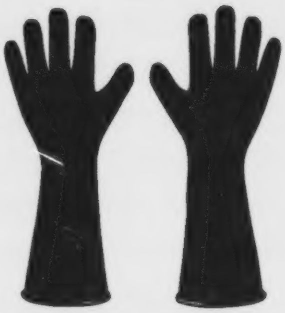
Note: All electricians and apprentices must carry a knife.

Figure 21



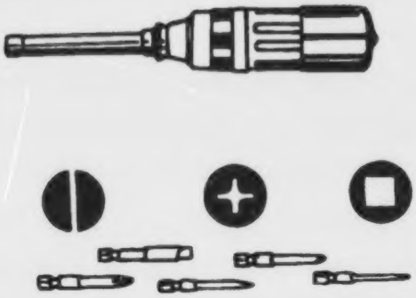
v. Rubber gloves

Figure 22



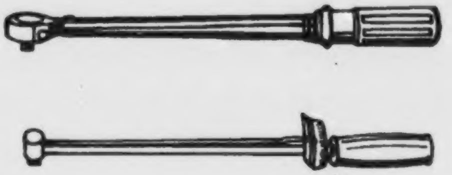
w. Torque screwdriver

Figure 23



x. Torque wrenches

Figure 24

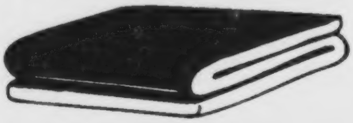


y. Rubber hose (line hose, snake)

Figure 25

z. Rubber blanket

Figure 26



Objective 4

Common hand tools and their uses

a. **Folding rule or tape measure**—Measuring distances on prints, conduit, cable, and so forth

b. **Flat-blade screwdriver**—Installing and removing slot-head screws

c. **Phillips screwdriver**—Installing and removing Phillips-head screws

d. **Slip-joint pliers**

- Holding couplings and conductors
- Tightening couplings and conductors
- Holding conduit
- Tightening and truing conduit

e. **Channel-lock wrench**—Gripping and turning work; versatile

f. **Hacksaw**

- Cutting large conductors and cables
- Cutting conduit
- Cutting metal for electronic cabinets

g. **Keyhole saw**—Cutting holes in plasterboard for circuit boxes

h. **File**

- Deburring large conduit
- Sharpening tools
- Deburring holes in circuit boxes
- Cleaning soldering gun tips and soldering iron

i. **Chisel**—Notching wood for boxes or cables

j. **Center punch**—Making center tap for drilling

k. **Bolt cutter**—Cutting large bolts, chains, locks, and so forth

l. **Hex key set (Allen wrenches)**—Installing and removing Allen screws

m. **Magnetic torpedo level**

- Leveling conduit
- Leveling equipment

n. **Knockout punch**—Cutting large holes in metal boxes without drilling

Note: Thick or very hard metal cannot be cut with a knockout punch. Also, in some tight areas, it is inconvenient to use a knockout punch.

o. **Hole saw**—Cutting large holes in metal

p. **Drill brace and drill**—Boring holes for conduit cable

q. **PVC cutter**—Cutting PVC pipe to specific lengths

r. **Taps**

- Equipping drill holes with bolt threads
- Retapping damaged threads
- Determining bolt size

s. **Masonry paddle bit**—Cutting round holes in masonry

t. **Vise stand**—Braces pipe for cutting, reaming or threading

u. **Screw-holding screwdriver**—Holding screw for use in limited-space installation

Objective 5

Electricity-specific hand tools and their uses

a. **Needle-nose pliers**

- Forming loops on small conductors
- Cutting small conductors
- Holding conductors while soldering
- Stripping insulation from conductors when equipped with #12 stripper

b. **Diagonal pliers (dykes)**

- Cutting small conductors
- Cutting conductors in limited spaces

c. **Lineman's pliers**

- Cutting large conductors
- Forming loops on large conductors
- Pulling and holding large conductors

d. **Adjustable wire stripper**

- Stripping insulation from conductors
- Cutting small conductors

e. **Cutting/crimping tool**

- Stripping insulation from conductors
- Cutting small conductors and bolts
- Cutting small bolts
- Crimping wire lugs

f. **Tool pouch**

- Holding tools
- Keeping tools organized

g. **Circuit tester**
   - Checking circuits for power
   - Checking fuses and breakers

h. **Conduit reamer**—Reaming burrs from cut conduits and EMT

i. **Nut driver**
   - Installing and removing nuts and bolts
   - Tightening and loosening nuts and long bolts

j. **Cable bender**—Assisting in bending large cables

k. **Fuse puller**—Removing fuses safely from equipment and circuit panels

   Note: Fuse pullers are insulated in order to prevent shock, but power must be turned off first for safety.

l. **Safety glasses and goggles**—Protecting eyes from foreign objects and liquids

m. **Electrician's hammer**
   - Driving and pulling nails
   - Opening wooden crates
   - Breaking plasterboard

n. **Cable cutter**—Cutting large copper or aluminum cables

o. **Drop chain**—Pulling cables through wall

p. **Steel fish tape and reel**
   - Pulling conductors through conduit
   - Pulling cables through insulated walls

q. **Pulling grip-sleeve**—Pulling in conduit, tray, or overhead lines

r. **Pipe reamer**—Deburring conduit

s. **Conduit bender**—Bending conduit for conductor installation

t. **Hickey bender**—Bending heavy conduit

u. **Electrician's knife**
   - Opening paper cartons
   - Stripping large conductors
   - Stripping cables

- Tightening and loosening small screws when screwdriver is not available

  Note: Some electrician's knives are equipped with screwdriver blades.

v. **Rubber gloves**—Protects wearer against electrical shock when working around energized electrical equipment

w. **Torque screwdriver**—Tightening slotted lugs and screws to manufacturer's torque specifications

x. **Torque wrenches**—Tightening Allenhead and bolt-type lugs to manufacturer's specifications

y. **Rubber hose (line hose, snake)**—Insulating and protecting technician from high-power, uninsulated overhead lines

z. **Rubber blanket**—Insulating and protecting technician from electrical current

Note: The blanket is laid over cabling or exposed conductor to protect the technician from accidental contact.

Objective 6

Factors to consider when purchasing tools

a. Size

Note: Always purchase the correct sized tool for the work to be done

b. Design

Examples: Insulated handles, hammers with straight claws

Note: Tool should be designed specifically for electrical work.

c. Quality

Note: The purchase of quality tools saves replacement cost.

Objective 7

Rules for care of various hand tools

Note: All tools should be used only for the purpose intended. It is the electrician's responsibility to keep his or her tools sharp, clean, and lubricated. A well-maintained tool has a longer life and is safer than an improperly maintained tool.

a. **Screwdrivers**

- Discard worn or damaged flat-blade screwdrivers.
- Discard Phillips screwdrivers with damaged tips.

b. **Pliers**

- Keep clean and free of rust.
- Keep cutting edges sharp.
- Keep pliers working freely.
- Replace damaged handle insulation.

c. **Adjustable wrenches**—Keep worm gears clean and lubricated.

d. **Cutting tools**

Examples: Saws, punches, chisels, drills, knives

- Keep cutting edges sharp.
- Protect cutting edges.
- Keep tools clean and lubricated.

Unit 6

Powered/Specialty Tools and Equipment

Unit Contents

Student Components

Student Page

Learning Activities Sheet 6–3

Objective Sheet 6–7

Information Sheet 6–9

* Assignment Sheet

1—Determine Dimensions on a Drawing Using an Architect's Scale 129

* Job Sheets

1—Use a Hydraulic Knockout Punch 133
2—Bend a 90-Degree Stub Using a Hydraulic Pipe Bender 137
3—Make Offset and 90-Degree Bends Using an Electric PVC Heater 139
4—Cut, Ream, and Thread Rigid Conduit with a Power Threader 145
5—Measure Resistance Using a VOM 149
6—Measure DC Voltages using a VOM 151
7—Measure AC Voltages using a VOM 153
8—Measure Amperage Using a Clamp-on Ammeter 157
9—Determine Current of a Multiple Loop Using a Clamp-on Ammeter 159
10—Check Conductor Insulation with a Megger 161

* Assignment Sheet and Job Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet

☐ 3. **Stop** Ask instructor to evaluate the completed focus assignment. After work has been evaluated, follow instructor's recommendations.

☐ 4. **Study** Information Sheet, Objectives 1 thru 7.

☐ 5. **Do** Job Sheet 1, "Use a Hydraulic Knockout Punch".

☐ 6. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 5.

☐ 7. **Study** Information Sheet, Objectives 8 and 9.

☐ 8. **Do** Job Sheet 2, "Bend a 90-Degree Stub Using a Hydraulic Pipe Bender".

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 8.

☐ 10. **Study** Information Sheet, Objectives 10 and 11.

☐ 11. **Do** Job Sheet 3, "Make Offset and 90-Degree Bends Using an Electric PVC Heater".

☐ 12. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 11.

☐ 13. **Study** Information Sheet, Objectives 12 thru 25.

☐ 14. **Do** Job Sheet 4, "Cut, Ream, and Thread Rigid Conduit With A Power Threader".

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 14.

☐ 16. **Study** Information Sheet, Objective 26.

☐ 17. **Do** Assignment Sheet 1, "Use An Architect's Scale To Measure Line Lengths."

☐ 18. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, repeat steps 16 and 17.

☐ 19. **Study** Information Sheet, Objectives 27a and c.

☐ 20. **Do** Job Sheets 5 thru 7, "Measure Resistance/DC Voltages/AC Voltages Using a VOM," in succession. See step 21.

☐ 21. **Stop** After completing each job sheet, have the instructor evaluate your performance. If the evaluation is satisfactory, continue to the next Job Sheet. If the evaluation is not satisfactory, study the procedure outlined in that Job Sheet, and redo the Job Sheet. After satisfactorily completing Job Sheets 5 thru 7, continue to step 22.

☐ 22. **Study** Information Sheet, Objective 27b.

☐ 23. **Do** Job Sheets 8 and 9, "Measure Amperage Using a Clamp-On- Ammeter," and " Determine the Current of a Multiple Loop Using a Clamp-On-Ammeter," in succession. See step 24.

☐ 24. **Stop** After completing each Job Sheet, have the instructor evaluate your performance. If the evaluation is satisfactory, continue to the next job sheet. If the evaluation is not satisfactory, study the procedure outlined in that Job Sheet, and redo the Job Sheet. After satisfactorily completing Job Sheets 8 and 9, continue to step 25.

☐ 25. **Study** Information Sheet, Objective 27d.

☐ 26. **Do** Job Sheet 10, "Check Conductor Insulation With a Megger".

☐ 27. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 28. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 10 and repeat Step 26.

☐ 28. **Check** With instructor for any additional assignments to be completed.

☐ 29. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 30. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and use common electrical specialty tools and equipment, including rules, scales, and test equipment. The student should demonstrate these competencies by completing assignment sheets and job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to specialty tools and equipment with their definitions.
2. Label common powered tools.
3. Match common powered tools with their uses.
4. List typical powered/specialty equipment.
5. Select true general safety rules for using powered specialty equipment.
6. Label the parts of a hydraulic knockout set.
7. Compete safety rules for using hydraulic knockout sets.
8. Label the parts of a hydraulic pipe bender.
9. Select true safety rules for using hydraulic pipe benders.
10. Label the parts of a polyvinylchloride (PVC) heater.
11. Complete safety rules for using polyvinylchloride heaters and blankets.
12. Label the parts of a power drill.
13. Select true safety rules for using power drills.
14. Label the parts of a power cable puller.
15. Complete safety rules for using power cable pullers.
16. Label the parts of portable and table bandsaws.
17. Complete safety rules for using portable and table bandsaws.
18. Label the parts of a dieless hydraulic crimper.
19. List safety rules for using hydraulic crimpers.

Objective Sheet

20. Label the parts of a hammer drill.
21. List safety rules for using hammer drills.
22. Label the parts of a core drilling machine.
23. Complete safety rules for using a core drilling machine.
24. Label the parts of a portable power threader.
25. Complete safety rules for using power threaders.
26. Identify typical scale used in the electrical industry.
27. Identify typical electrical test equipment.
28. Determine Dimensions on a Drawing Using an Architects Scale. (Assignment Sheet 1)
29. Use a hydraulic knockout punch. (Job Sheet 1)
30. Bend a 90-degree stub using a hydraulic pipe bender. (Job Sheet 2)
31. Make offset and 90-degree bends using an electric PVC heater. (Job Sheet 3)
32. Cut, ream, and thread rigid conduit with a power threader. (Job Sheet 4)
33. Measure resistance using a VOM. (Job Sheet 5)
34. Measure DC voltages using a VOM. (Job Sheet 6)
35. Measure AC voltages using a VOM. (Job Sheet 7)
36. Measure amperage using a clamp-on ammeter. (Job Sheet 8)
37. Determine the current of a multiple loop using a clamp-on ammeter. (Job Sheet 9)
38. Check conductor insulation with a megger. (Job Sheet 10)

Information Sheet

Objective 1

Terms and definitions

a. **Accuracy**—How near the instrument reading is to the actual value

b. **Amperage**—Electricity; electrical current flow; electron flow; must be measured at a point within a circuit

c. **Bender**—Tool used to make various angles or bends in conduit

d. **Calibration**—Technique of testing and adjusting an instrument by referring it to another instrument or device of known accuracy and precision

e. **Chuck**—Portion of drill that holds the bit

f. **Cross handle** (T-handle)—Handle set across a power tool to prevent the tool from turning

g. **Cutter**—Hardened steel device used to cut holes in metal boxes

h. **Die**—Component that backs up cutter on opposite side of metal box

i. **Error**—How far a measurement is from the actual value

j. **Ground**—Electrical point or any good conductor that is connected to a common chassis with zero relative voltage; usually conductors are connected to the earth

k. **Hydraulic**—Using pressurized fluid to accomplish work

l. **Hydraulic oil**—Specially formulated oil for hydraulic pumps

Note: No oil or fluid should ever be substituted for hydraulic oil.

m. **Knockout punch**—Device used to make openings for conduit in metal enclosures

n. **Multimeter**—Instrument capable of measuring a "multiple" of values

Examples: Amperage, voltage, and resistance with several measurement ranges

o. **Parallax correction**—Viewing analog VOM from directly above the needle to avoid the possibility of wrong readings due to depth perception

p. **Pinch point**—Any opening that may close and bind a finger or hand

q. **Polyvinylchloride (PVC) conduit**—Plastic pipe

r. **Precision**—Instrument consistency

Example: A "precision meter" might not be accurate. It may measure 1 volt at 1.20 volts, but each time the reading will be precisely 1.20, not 1.21 or 1.10. A calibration adjustment could correct the meter reading to 1.00 at 1 volt and would then precisely repeat a 1.00 reading.

s. **Ram**—Device used to transfer hydraulic pressure to a mechanical device

t. **Resistance**—Opposition to electrical current flow; measured in units of ohms; must be measured from one point to another

u. **Resolution**—How well an instrument will indicate a small change in the measured value

Example: A precise, accurate, and sensitive meter may respond by moving the meter hand $^{1}/_{6}$" for a small change in measured amperage. If the scale is marked only one division per inch, the meter would still lack "resolution" since the operation could not determine what amount of current change this represents.

v. **Voltage**—Electromotive force (emf) that drives electricity through conductors; must be measured across or referenced to a second point

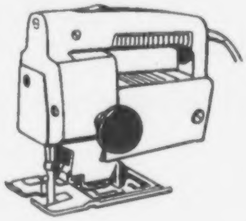
Example: Ground

Objective 2

Common powered tools

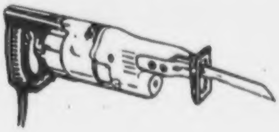
a. Sabre Saw

Figure 1



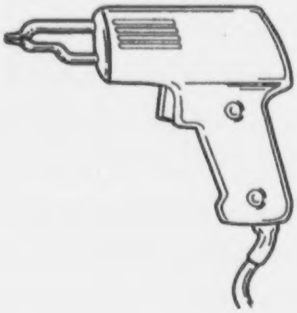
b. Reciprocating Saw

Figure 2



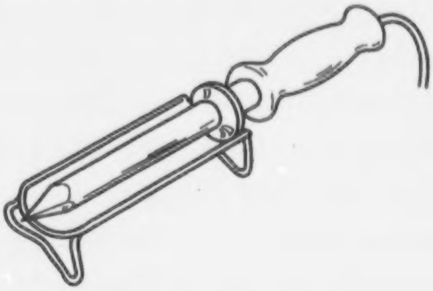
c. Soldering Gun

Figure 3



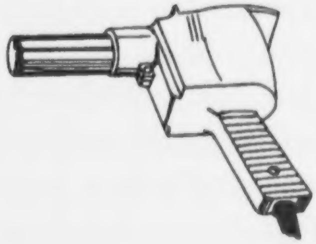
d. Soldering Iron

Figure 4



e. Heat Gun

Figure 5



Objective 3

Common powered tools and their uses

a. Sabre saw—Cutting holes in wood or plasterboard

b. Reciprocating saw—Cutting holes in wood or plasterboard (tighter areas)

c. Solder gun (approximately 250W)

- Soldering large conductors
- Splicing cables

d. Soldering iron (approximately 25W)

- Soldering small heat-sensitive components
- Soldering printed circuit boards

e. Heat gun

- Drying electronic components and conductors
- Heat shrinking

Objective 4

Typical powered specialty equipment

a. Hydraulic knockout set

b. Hydraulic pipe bender

c. PVC heaters and blankets

d. Power drill

e. Power cable puller

f. Portable and table band saws

g. Dieless hydraulic crimper

h. Hammer drill

i. Core drilling machine

j. Portable power threader

Objective 5

General safety rules for using powered equipment

a. Always follow manufacturer's operating instructions.

b. Never place hands in a pinch point.

c. Use eye protection.

d. Wear gloves when working with hot equipment or materials.

e. Always secure loose clothing such as shirt sleeves and shirttails.

f. Tie back long hair and do not wear dangling jewelry.

g. Never exceed rated capacity of equipment.

h. Never remove protective guards from equipment.

i. Be prepared for the unexpected.

Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

j. Replace damaged cords.

k. Do not unplug by pulling cord.

l. Lubricate moving parts.

m. Keep clean.

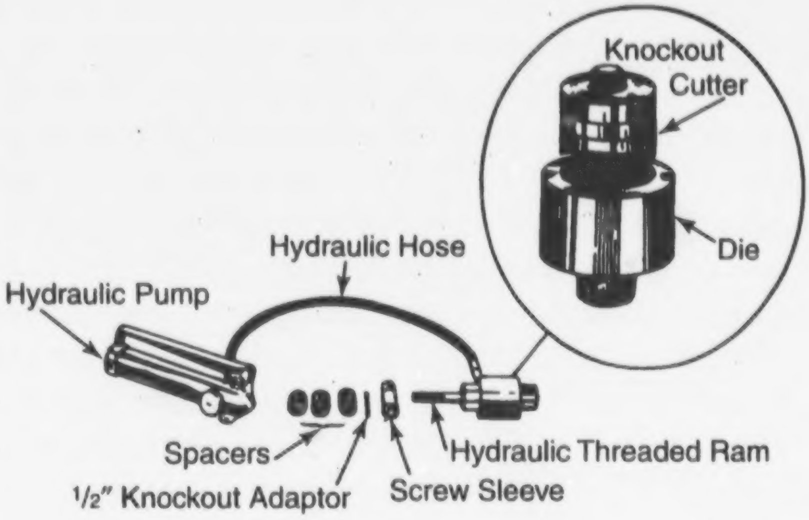
n. Store properly.

Information Sheet

Objective 6

Parts of a hydraulic knockout set

Figure 6


Knockout Cutter
Die
Hydraulic Hose
Hydraulic Pump
Spacers
1/2" Knockout Adaptor
Screw Sleeve
Hydraulic Threaded Ram

Objective 7

Safety rules for using hydraulic knockout sets

a. Never substitute brake fluid for hydraulic oil.

b. Never disconnect the hose when it is under pressure.

c. Do not use near live electrical parts.

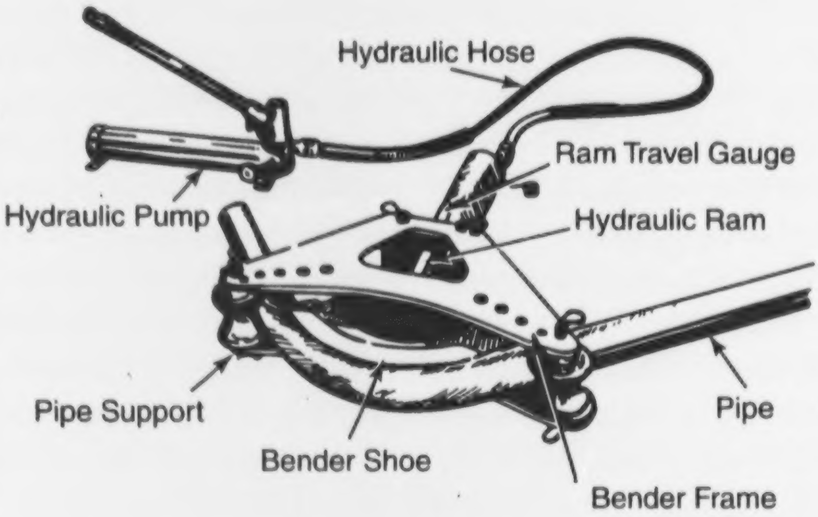
d. Never force the pump handle.

e. Always wear eye protection.

Objective 8

Parts of a hydraulic pipe bender

Figure 7


Hydraulic Hose
Ram Travel Gauge
Hydraulic Pump
Hydraulic Ram
Pipe Support
Pipe
Bender Shoe
Bender Frame

Objective 9

Safety rules for using hydraulic pipe benders

a. Never substitute brake fluid for hydraulic oil.

b. Never disconnect the hose when it is under pressure.

c. Never place hands near ram or shoe while bending.

d. Always use proper size conduit shoe and support.

e. Be sure that floor area is clear for pipe movement.

f. Lift heavy bender parts correctly.

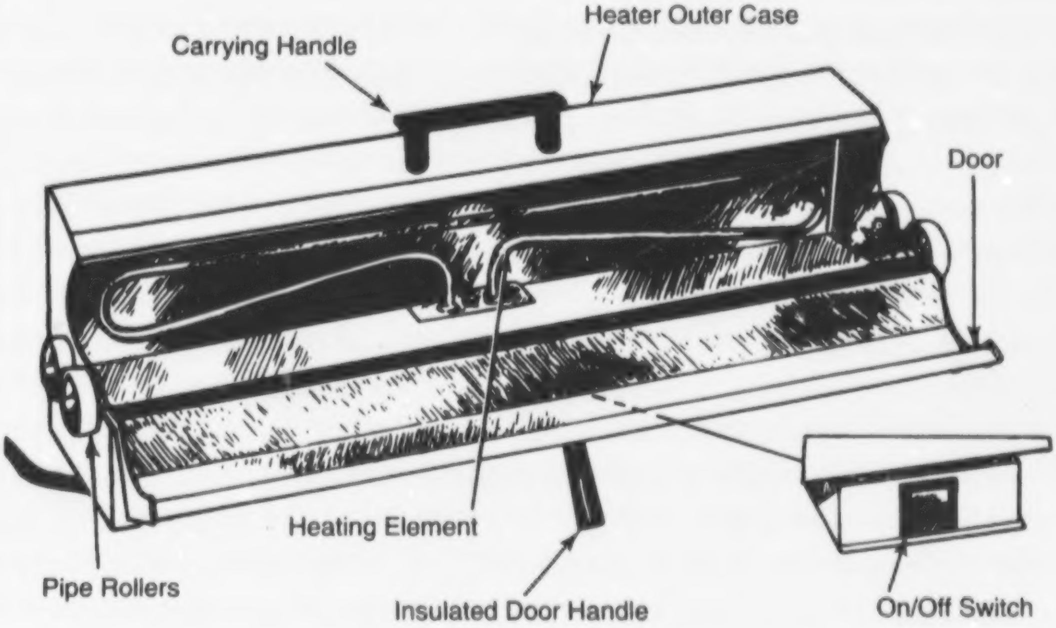
Note: Some bender parts weigh more than 50 pounds and require more than one person to assemble or move.

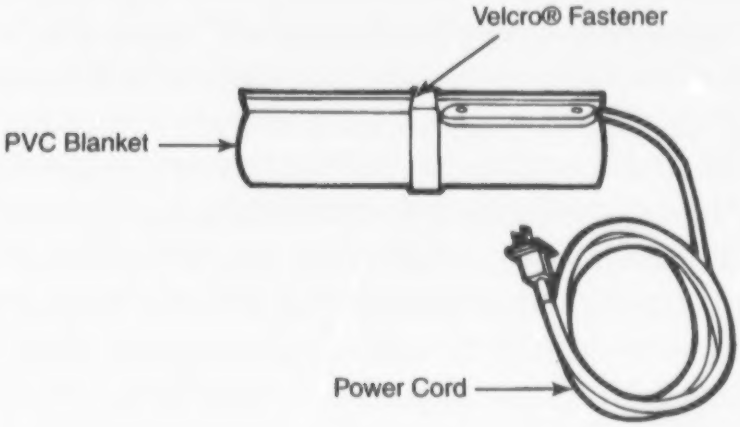
g. Make sure that the shoe, follow bar, saddle, pipe support, and other accessories are appropriate for the size and type conduit being bent.

Information Sheet

Objective 10 Parts of PVC heaters and blankets

Figure 8


Heater Outer Case
Carrying Handle
Door
Heating Element
Pipe Rollers
Insulated Door Handle
On/Off Switch


Velcro® Fastener
PVC Blanket
Power Cord

Objective 11

Safety rules for using PVC heaters and blankets

a. Never use in wet locations.

b. Always wear gloves when handling hot heater or pipe.

c. Use only with PVC conduit.

d. Use only for specified type and size of PVC conduit.

e. Always turn heater or blanket off when not in use.

f. Use only in a well-ventilated, noncluttered area.

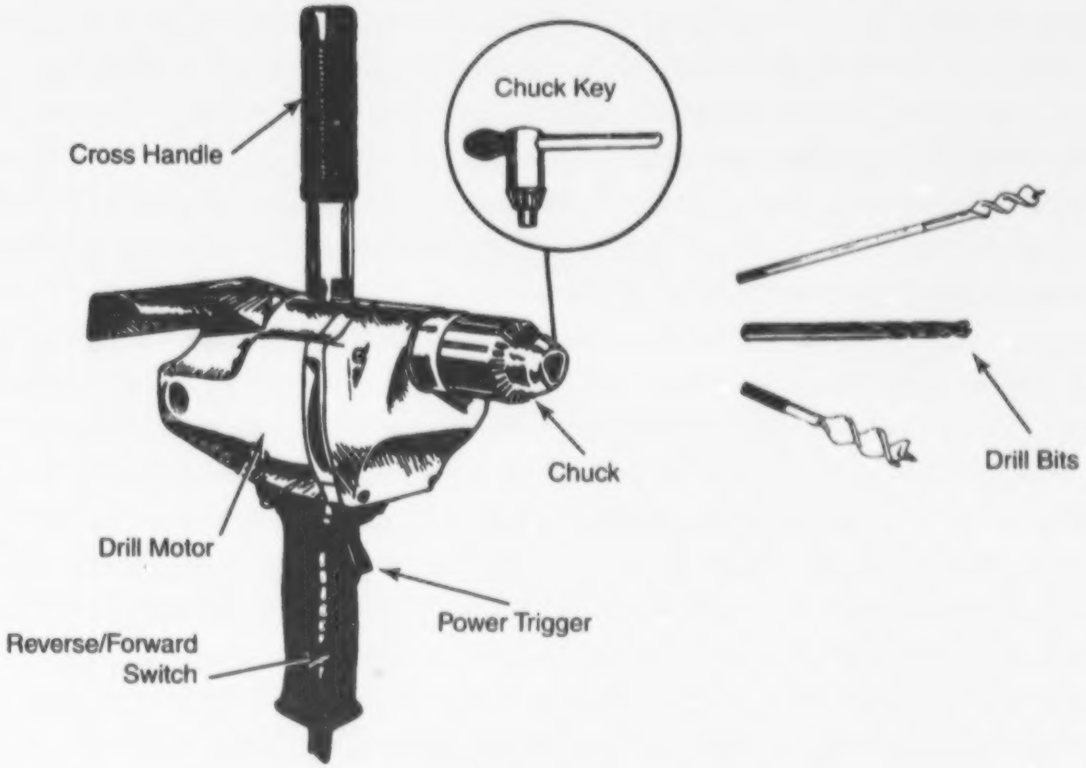
g. Never leave unattended while turned on.

h. Keep hands and other body parts from direct contact with hot surfaces.

Objective 12

Parts of a power drill

Figure 9


Chuck Key
Cross Handle
Drill Bits
Chuck
Drill Motor
Power Trigger
Reverse/Forward Switch

Objective 13

Safety rules for using power drills

a. Check area to be drilled for hidden wires or pipes.

b. Hold drill securely with both hands.

c. Place small objects to be drilled in a vise.

d. Always hold the drill steady and perpendicular to the work to prevent the bit from breaking or binding.

e. Always use a T-handle when drilling to allow you to secure the hammer drill when it encounters especially hard surfaces.

f. **Never** lock the trigger in the "on" position

g. Never drill while off balance.

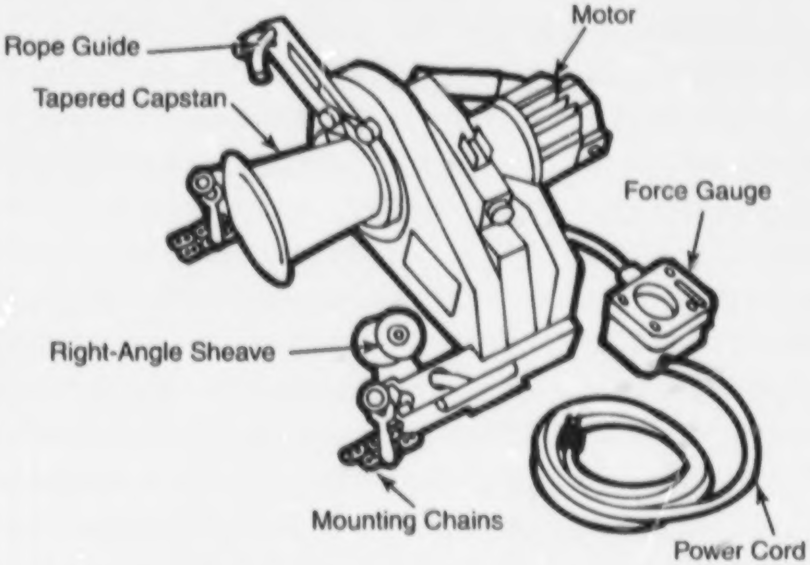
Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

h. Always wear eye protection.

Objective 14

Parts of a power cable puller

Figure 10


Rope Guide
Motor
Tapered Capstan
Force Gauge
Right-Angle Sheave
Mounting Chains
Power Cord

Objective 15

Safety rules for using a power cable puller

a. Ensure that all cable pulling systems, accessories, and rope have the proper load for the pull.

b. Mount and secure pulling unit according to manufacturer's instructions.

Note: These units create a tremendous amount of force and may cause injury if not mounted and secured properly.

c. Stand out of direct line of force.

Note: A broken rope or cable can whiplash with lethal force.

d. Monitor pull of force gauge, and never exceed maximum force.

Note: Most of today's power cable pullers are equipped with an audible alarm high force warning and a circuit breaker shut off at maximum force.

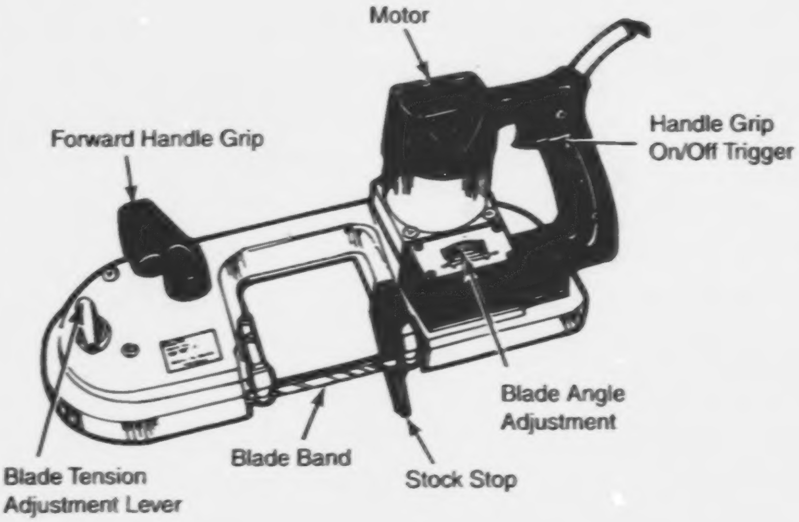
e. Always wear eye protection.

Objective 16

Parts of portable and table band saws

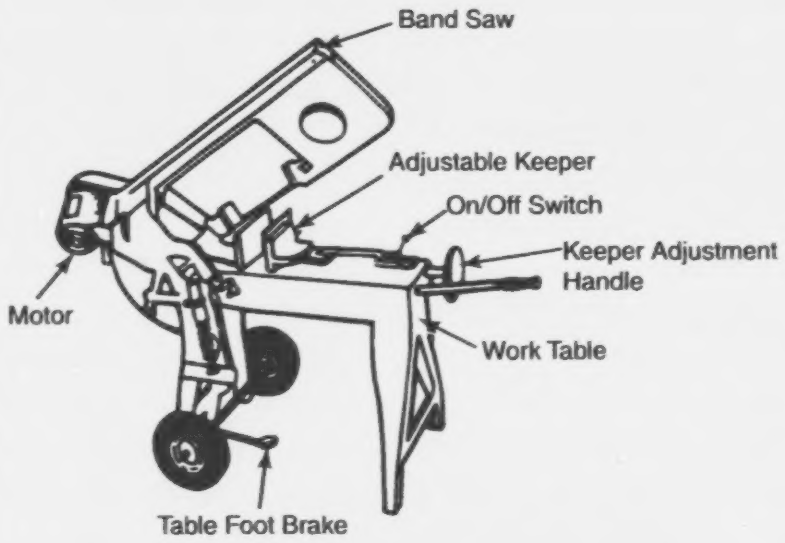
a. Portable band saw

Figure 11


Motor
Forward Handle Grip
Handle Grip
On/Off Trigger
Blade Angle
Adjustment
Blade Band
Stock Stop
Blade Tension
Adjustment Lever

a. Table band saw

Figure 12


Band Saw
Adjustable Keeper
On/Off Switch
Keeper Adjustment Handle
Motor
Work Table
Table Foot Brake

Objective 17

Safety rules for using portable and table bandsaws

a. Secure object to be cut in a vise or other stable rest.

b. Check the blade for missing teeth that could result in the blade binding or breaking.

c. Do not remove or alter safety guards.

d. Keep hands clear of the blade.

e. Never saw while off balance.

Note: Make sure your footing and body position are such that you will not lose balance in the event that the unexpected happens.

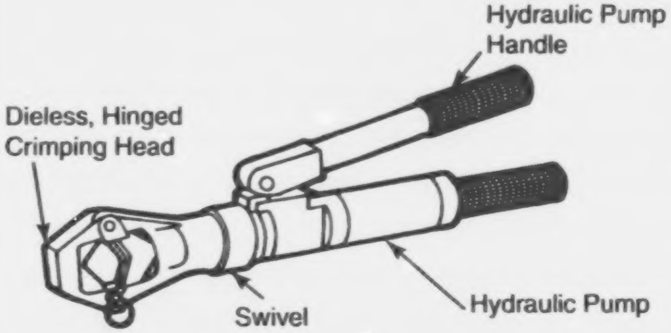
f. Always wear eye protection.

Objective 18

Parts of a dieless hydraulic crimper

Note: This model has a hinged crimping head for easy splice connector loading and unloading. The crimper swivel head also rotates 180 degrees for flexibility.

Figure 13


Hydraulic Pump Handle
Dieless, Hinged Crimping Head
Swivel
Hydraulic Pump

Objective 19

Safety rules for using hydraulic crimpers

a. Ensure that die is mounted securely on threading machine.

b. Keep die flooded with cutting oil during operation.

Note: This serves to cool the die as well as to lubricate it.

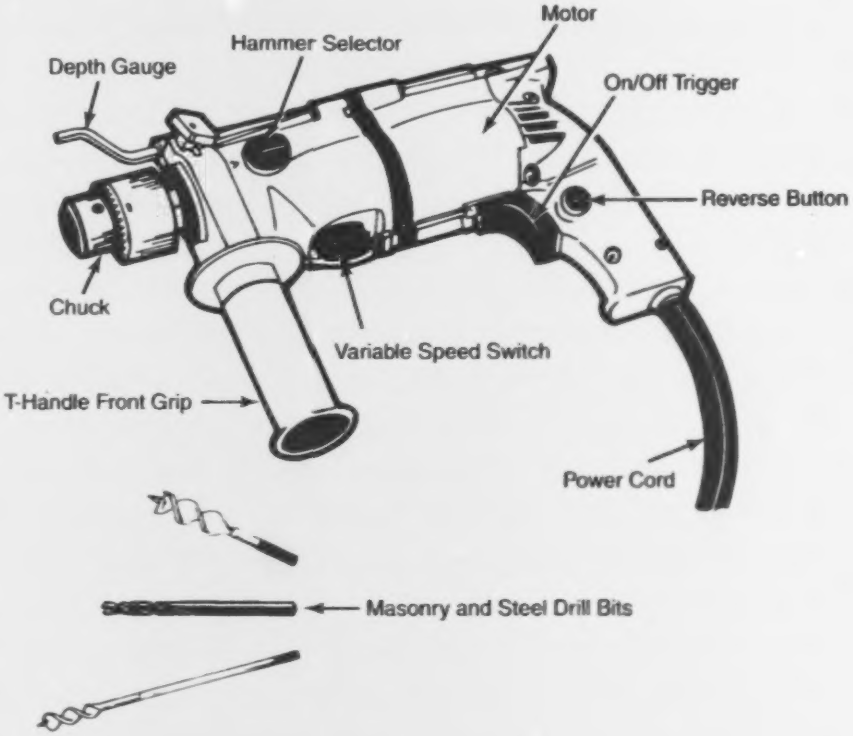
c. Keep hands, clothing, and hair always from rotating parts.

d. Always wear eye protection.

Objective 20

Parts of a hammer drill

Figure 14


Motor
Hammer Selector
Depth Gauge
On/Off Trigger
Reverse Button
Chuck
Variable Speed Switch
T-Handle Front Grip
Power Cord
Masonry and Steel Drill Bits

Objective 21

Safety rules for using a hammer drill

a. Always hold the drill steady and perpendicular to the work to prevent the bit from breaking or binding.

b. Always use a T-handle when drilling to allow you to secure the hammer drill when it encounters especially hard surfaces.

c. **Never** lock the trigger in the "on" position.

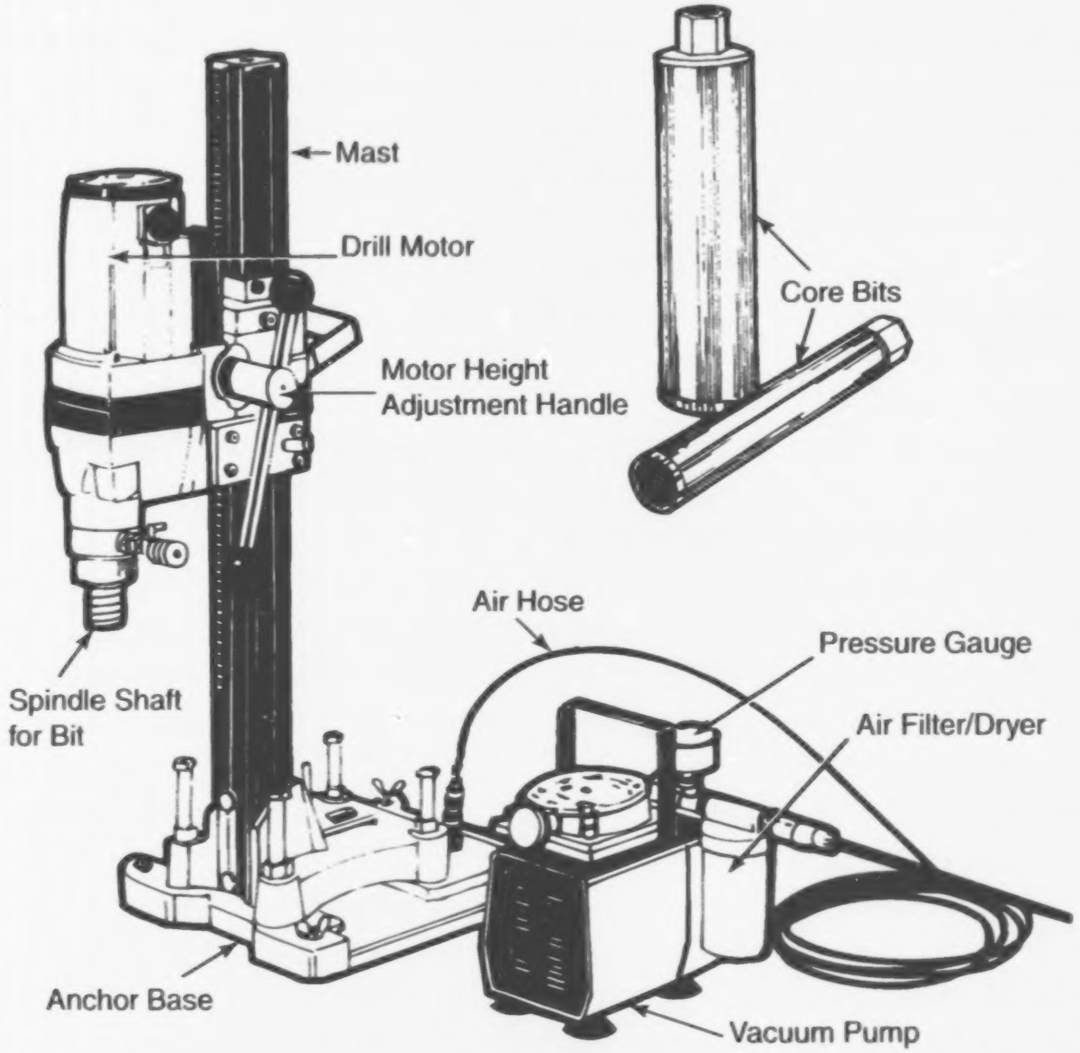
d. Never drill while off balance.

Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

e. Always wear eye protection.

Objective 22 **Parts of a core drilling machine**

Figure 15


Mast
Drill Motor
Core Bits
Motor Height Adjustment Handle
Air Hose
Pressure Gauge
Spindle Shaft for Bit
Air Filter/Dryer
Anchor Base
Vacuum Pump

Objective 23

Safety rules for using a core drilling machine

a. Ensure that the core drilling machine is securely mounted to the surface to be drilled.

b. Never leave the machine drilling while unattended.

c. Do not try to force the drill to cut faster than suggested by the manufacturer.

d. Never drill while off balance.

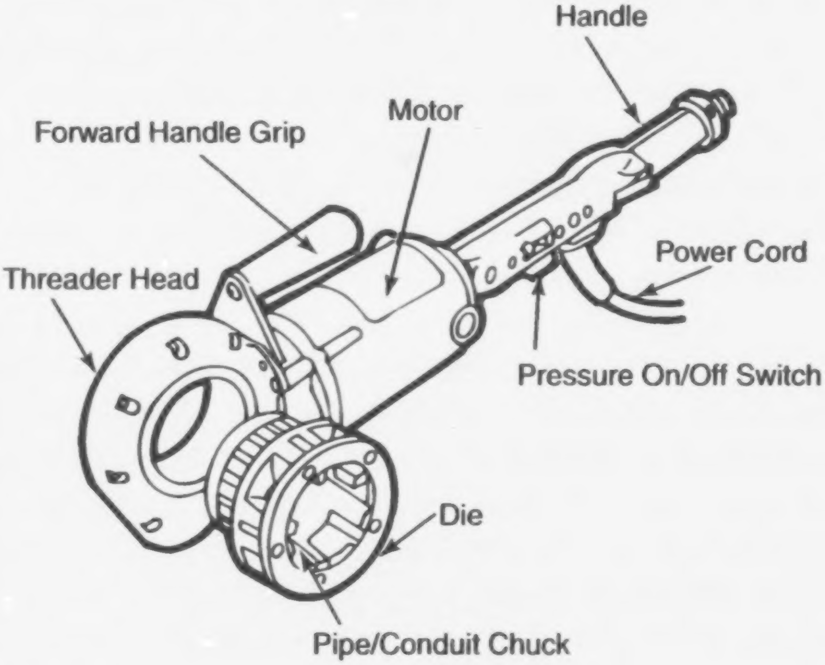
Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

e. Always wear eye protection.

Objective 24

Parts of a portable power threader

Figure 16


Handle
Motor
Forward Handle Grip
Power Cord
Threader Head
Pressure On/Off Switch
Die
Pipe/Conduit Chuck

Objective 25

Safety rules for using a portable power threader

a. Always wear eye protection.

b. Always wear tight-fitting clothing, tie back long hair, and remove dangling jewelry.

c. Use gloves when handling pipe/conduit.

d. Never place hands near turning pipe/conduit.

e. Let threader come to a complete stop before removing pipe/conduit or reversing direction.

f. Always use a brush, not your hands, to clear thread cuttings.

g. Never operate power threader while off balance.

Note: Make sure that your footing and body position are such that you will not lose balance in the event that the unexpected happens.

Objective 26

Architect's scale

a. Rules for reading a scale

- Check the title block to find the scale used on the drawing.
- Use the same scale to which the drawing was prepared.
- Lay the scale flat on the surface being measured.
- Double check all measurements.
- Measure from the center of one line to the center of the next line.
- Do not scale a drawing when dimensions are available.
- Read dimensions in the following order

(1) Feet marked ′

(2) Inches marked ″

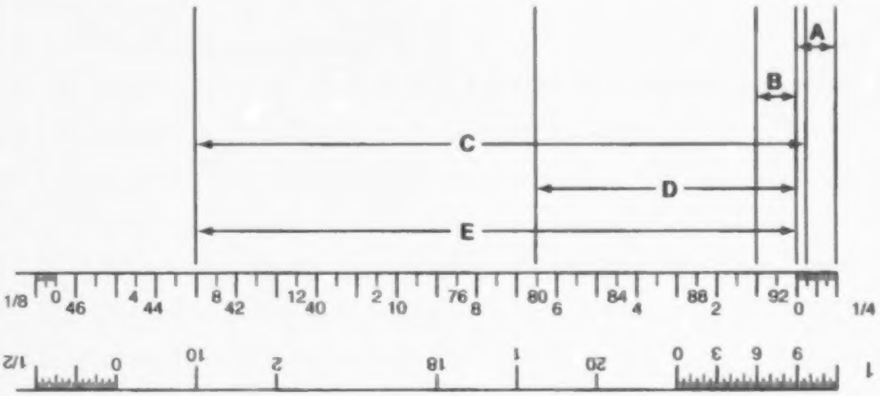
(3) Fractions of an inch

Note: Some scales read from right to left, while others read from left to right.

b. Commonly used scales for building plans

- $^1/_4$" = 1′
- $^1/_8$" = 1′ 0"
- $^1/_{16}$" = 1′ 0"
- 1" = 20′ and 1" = 50′ (common on plot plans)

Example: Practice reading the following $^1/_4$" scale ($^1/_4$" = 1′)


A
B
C
D
E
1/8
0
46
4
44
8
42
12
40
2
10
76
8
80
6
84
4
88
2
92
0
1/4
1/2
0
10
2
18
1
20
0
3
6
9
1

A—$^1/_4$" scale marked off in inches—$^1/_4$" = 1′

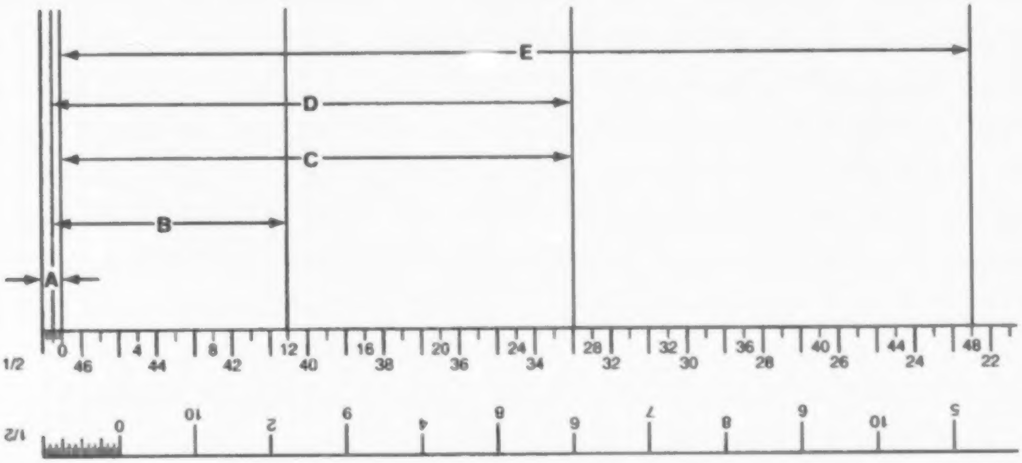
B—1′

C—43′-3"

D—6′-6"

E—43′

Example: Practice reading the following 1/8" scale (1/8" = 1'0")


E
D
C
B
A
1/2
0
4
8
12
16
20
24
28
32
36
40
44
48
46
44
42
40
38
36
34
32
30
28
26
24
22

A—1/8" scale marked off in inches—1/8" = 1'

B—12'-6"

C—27'

D—27'-6"

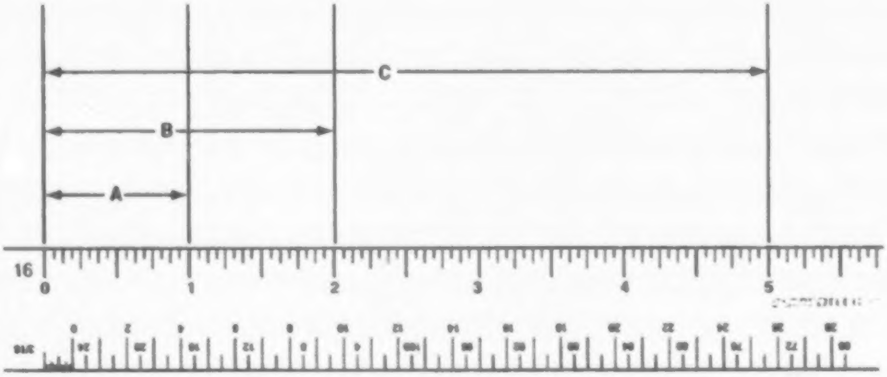
E—48'

c. Commonly used scales for plot plans

- 1″ = 20′
- 1″ = 50′

Note: The plan will specify 1″ = 20′, 1″ = 50′or other suitable scale.

Example:



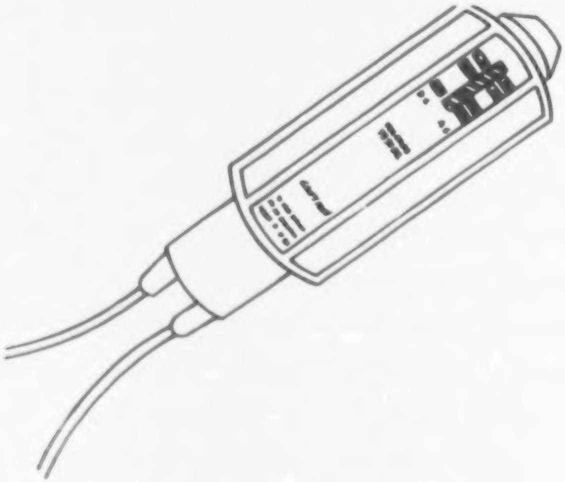
at 1″ = 20′	at 1″ = 100′
A—20′	A—100′
B—40′	B—200′
C—100′	C—1000′

Objective 27

Typical test equipment

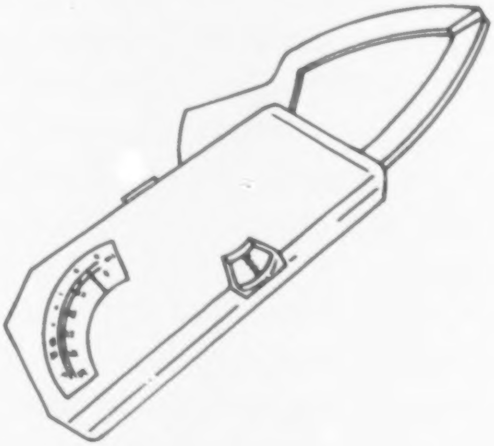
a. **Voltage tester**—Used to determine the presence of voltage at a power source; indicated *approximate* value of voltage present

Figure 17



b. **Clamp-on ammeter**—Designed to clamp around an energized conductor and indicate the value of the current flowing through the conductor; can measure higher current values than a VOM can

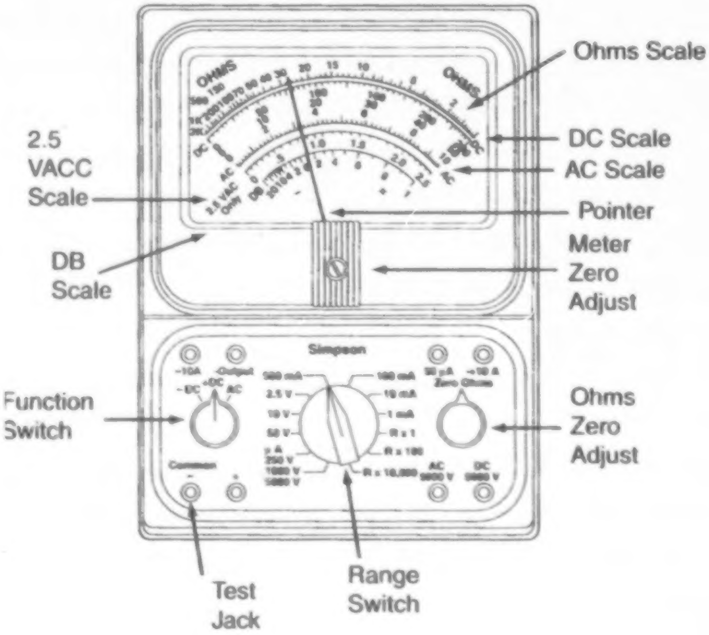
Figure 18



c. **Permanent magnet moving coil multimeter (VOM)**—Designed to indicate specific quantities of voltage, resistance, or amperage

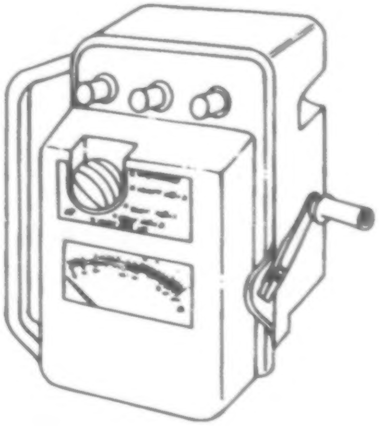
Note: "VOM" means volt-ohm-meter.

Figure 19


Ohms Scale
DC Scale
AC Scale
2.5 VACC Scale
Pointer
DB Scale
Meter Zero Adjust
Simpson
Function Switch
Ohms Zero Adjust
Test Jack
Range Switch

d. **Megometer (Megger)**—Typically used to test conductor insulation; able to measure insulation or ground resistance of several million ohms

Figure 20



Unit Contents

Student Components

Student Page

Learning Activities Sheet 7–3

Objective Sheet 7–5

Information Sheet 7–7

* Focus Assignment

Using the *National Electrical Code* 163

* Assignment Sheets

1—Use the *National Electrical Code* index to answer questions about *Code* sections 165
2—Use the *National Electrical Code* title page, table of contents, and introduction to answer questions 167
3—Use the *National Electrical Code* first chapter to define terms 169
4—Use the *National Electrical Code* to answer general questions related to residential wiring 173
5—Use the *National Electrical Code* to locate allowable ampacities for various conductors 175
6—Use the *National Electrical Code* to interpret conduit fill tables 177
7—Find information in the *National Electrical Code* 181

* Focus Assignment and Assignment Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

Optional ☐ 3. **View** Videotapes 1 and 2 from the NEC Video Set.

☐ 4. **Do** Focus Assignment, "Using the *National Electrical Code.*"

☐ 5. **Study** Information Sheet, Objectives 1 through 7.

☐ 6. **Do** Assignment Sheet 1, "Use the *National Electrical Code* Index to Answer Questions about *Code* Sections."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 and 6.

Optional ☐ 8. **View** Videotapes 3 and 4 from the NEC Video Set.

☐ 9. **Do** Assignment Sheet 2, "Use the *National Electrical Code* Title Page, Table of Contents, and Introduction to Answer Questions."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 5 and 9.

☐ 11. **Do** Assignment Sheet 3, "Use the *National Electrical Code* First Chapter to Define Terms."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat Steps 5 and 11.

☐ 13. **Do** Assignment Sheet 4, "Use the *National Electrical Code* to Answer Questions Related to Residential Wiring."

☐ 14. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, repeat Steps 5 and 13.

☐ 15. **Do** Assignment Sheet 5, "Use the *National Electrical Code* to Locate Allowable Ampacities for Various Conductors."

☐ 16. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat Steps 5 and 15.

☐ 17. **Do** Assignment Sheet 6, "Use the *National Electrical Code* to Interpret Conduit Fill Tables."

☐ 18. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, repeat Steps 5 and 17.

☐ 19. **Do** Assignment Sheet 7, "Find information in the *National Electrical Code.*"

☐ 20. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 21. If the evaluation is not satisfactory, repeat Steps 5 and 19.

☐ 21. **Check** With instructor for any additional assignments to be completed.

☐ 22. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 23. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to locate specific wiring installation information in the *National Electrical Code*. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to using trade information with their definitions.
2. State the purposes of the *National Electrical Code*.
3. List factors that are not covered by the *National Electrical Code*.
4. State the intent of the *National Electrical Code* regarding mandatory enforcement.
5. Match *National Electrical Code* chapter numbers with their areas of application.
6. Arrange in order the sequence of organizational components of *National Electrical Code* information.
7. Arrange in order the steps for finding information in the *National Electrical Code*.
8. Using the *National Electrical Code*. (Focus Assignment)
9. Use the *National Electrical Code* index to answer questions about *Code* sections. (Assignment Sheet 1)
10. Using the *National Electrical Code* title page, table of contents, and introduction to answer questions. (Assignment Sheet 2)
11. Use the *National Electrical Code* first chapter to define terms. (Assignment Sheet 3)
12. Use the *National Electrical Code* to answer general questions related to residential wiring. (Assignment Sheet 4)
13. Use the *National Electrical Code* to locate allowable ampacities for various conductors. (Assignment Sheet 5)
14. Use the *National Electrical Code* to interpret conduit fill tables. (Assignment Sheet 6)
15. Find information in the *National Electrical Code*. (Assignment Sheet 7)

Information Sheet

Objective 1

Terms and definitions

a. **American National Standards Institute (ANSI)**—Develops standards for electrical equipment and supplies

b. **American Standard Association (ASA)**—Develops standards for electrical machinery and equipment

c. **Bonding**—Permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed

d. **Bonding jumpers**—A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected

e. **Bonding jumper circuit**—Connections between portions of a conductor in a circuit to maintain required ampacity of the circuit

f. **Bonding jumper equipment**—Connections between two or more portions of the equipment grounding conductor

g. **Building code**—Standards developed to provide for safe building construction practices

h. **Grounded**—Connected to earth or to some conduction body that serves in place of the earth

i. **Grounded conductor**—Intentionally grounded system or circuit conductor (neutral)

j. **Grounding conductor**—Conductor used to connect equipment of the grounded circuit of a wiring system to a grounding electrode or electrodes

k. **Grounding electrode conductor**—Conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system

l. **Jurisdiction**—Power, right, or authority to interpret the law (code)

m. **Mandatory enforcement**—Governmental authority to demand compliance with the *National Electrical Code* requirements for electrical installations

n. ***National Electrical Code* (*NEC*)**—Book containing electrical specifications endorsed by NFPA and ANSI; used for legal and regulatory purposes in the interest of life and property protection

o. **National Electrical Manufacturers Association (NEMA)**—Develops electrical equipment standards

p. **National Fire Protection Association (NFPA)**—Develops and publishes fire and industrial safety standards

q. **Underwriters Laboratories (UL)**—Tests equipment and lists items for use in specified situations

Information Sheet

Objective 2

Purpose of the *National Electrical Code*—The practical safeguarding of persons and property from hazards arising from the use of electricity

Objective 3

Factors that are not covered by the *National Electrical Code*

a. Efficiency

b. Convenience

c. Adequate for good service or future expansion

Objective 4

Intent of the *National Electrical Code* regarding mandatory enforcement—The *Code* is intended to be suitable for mandatory application by the governmental authority having jurisdiction. Mandatory rules are characterized by the word "SHALL" or "SHALL NOT."

Note: The local inspector may grant exception (special permission) to *Code* requirements, provided safety standards are maintained. States and municipalities may adopt their own electrical codes as long as these codes improve upon, not lessen, the requirements of the *NEC*.

Objective 5

***National Electrical Code* chapter numbers and their areas of application**

a. **Chapter 1**—General

b. **Chapter 2**—Wiring and protection

c. **Chapter 3**—Wiring methods and materials

d. **Chapter 4**—Equipment for general use

e. **Chapter 5**—Special occupancies

f. **Chapter 6**—Special equipment

g. **Chapter 7**—Special conditions

h. **Chapter 8**—Communications systems

i. **Chapter 9**—Tables

Objective 6

Sequence of organizational components of *National Electrical Code*

a. **Chapter**—Covers broad area of *Code*

Example: Chapter—Wiring Design and Protection

b. **Article**—Covers a specific part of the chapter

Example: Article 210—Branch circuits

c. **Parts**—Covers a specific item of the article

Example: Part II—Branch circuit ratings

d. **Numbered paragraphs**—Cover a specific item of the part

Example: Paragraph 19—Conductors—Minimum ampacity and size

e. **Numbered (1) or uppercase lettered (A) subparagraphs**

Example: Subparagraph (3)—Household ranges and cooking appliances

Objective 7

Steps for finding information in the *National Electrical Code*

a. Refer to index for appropriate area of *Code*

Example: Service drops (locate by using a keyword)

b. Locate specified area in question.

Example: Minimum size

c. Turn to article and section as designated.

Example: Service drops—minimum size—230.23

d. Read all related areas and exceptions

e. Cross-reference if *Code* refers to another article.

Note: It is imperative that all cross references be found and read, otherwise the improper answer may be used.

Example: **Incandescent lamps**, Art. 410; see also
    Hazardous (classified) locations
Guards
    Aircraft hangers, 513.7(C)
    Garages, 511.7(A) and (B)
    Theater dressing rooms, 520.72
Lamp wattage, marking on luminaire (fixture), 410.70
Medium and mogul bases, 410.53
Snap switches for, 404.14(B)(3)

Unit Contents

Student Components

Student Page

Learning Activities Sheet 8–3

Objective Sheet 8–5

Information Sheet 8–7

* Assignment Sheet

1—Determine the Correct Number of Conductors for Boxfill 187

* Job Sheets

1—Install Outlet Boxes on Wood Studs on a Framed Wall 191
2—Install Outlet Boxes on Steel Structures and Rods Using Caddy Clips 197
3—Install Outlet Boxes on Steel Studs Using Caddy Metal Clips for Switch Boxes 201
4—Install Masonry Boxes in a Block Wall Using Caddy Metal Clips for Switch Boxes 205

* Assignment Sheet and Job Sheets are located in Student Workbook 1.

677

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet

☐ 3. **Re-Search** Online resources regarding pricing and availability of basic equipment. Visit www.grainger.com as one of your resources. Click on "browse our catalog," type in "electrical," and hit enter.

☐ 4. **Study** Information Sheet, Objectives 1,2, and 3.

☐ 5. **Do** Assignment Sheet 1, "Determine The Correct Number Of Conductors For Boxfill".

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 4 and 5.

☐ 7. **Study** Information Sheet, Objectives 4 thru 9.

☐ 8. **Do** Job Sheet 1, " Install Outlet Boxes On Wood Studs On A Framed Wall".

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 8.

☐ 10. **Study** Information Sheet, Objective 10.

☐ 11. **Do** Job Sheet 2, "Install Outlet Boxes On Steel Structures And Rods Using Caddy Clips".

☐ 12. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 11.

☐ 13. **Do** Job Sheet 3, " Install Outlet Boxes On Steel Studs Using Caddy Metal Stud Clips For Switch Boxes".

☐ 14. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 13.

☐ 15. **Do** Job Sheet 4, "Install Masonry Boxes In A Block Wall".

☐ 16. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 15.

☐ 17. **Check** With instructor for any additional assignments to be completed.

☐ 18. **Take** Posttest provided by instructor. After the test has been evaluated, follow instructor's recommendations.

☐ 19. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and install electrical boxes and enclosures used in the electical field. The student should demonstrate these competencies by completing the assignment sheets and job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic equipment with their correct definitions.
2. Identify classes of outlet boxes used in electrical wiring.
3. List information needed to calculate boxfill.
4. Match types of enclosures with their conditions for use.
5. State the purposes of controller enclosures.
6. Label types of devices commonly used in electrical wiring.
7. Label types of covers and plates used in electrical wiring.
8. Identify supports and anchors commonly used in electrical wiring.
9. Identify screws, bolts, and nuts commonly used in electrical wiring.
10. Identify classes of box mounting devices for steel structures.
11. Determine the correct number of conductors for boxfill. (Assignment Sheet 1)
12. Install outlet boxes on wood studs on a framed wall. (Job Sheet 1)
13. Install outlet boxes on steel structures and rods using caddy clips. (Job Sheet 2)
14. Install outlet boxes on steel studs using Caddy metal stud clips for switch boxes. (Job Sheet 3)
15. Install masonry boxes in a block wall. (Job Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Boxfill**—Number of conductors of a certain size permitted in a box; number is based on cubic inches of box

b. **Cabinet**—Enclosure designed either for surface or flush mounting; provided with a frame, mat, or trim in which a swinging door or doors may be hung

c. **Disconnecting means**—Device, or group of devices, or other means by which circuit conductors can be disconnected from their source of supply

d. **Dustproof**—So constructed or protected that dust will not interfere with successful operation

e. **Dusttight**—So constructed that dust will not enter the enclosing case

f. **Explosionproof**—Capable of containing hot explosive flames within the enclosure to prevent explosions in the surrounding atmosphere

g. **Joint Industry Conference (JIC) boxes**—Boxes or enclosures made to Joint Industry Conference standards for such uses as junction boxes and housing terminal blocks

h. **Junction boxes**—Enclosurers designed for conduit or cable entrances to enclose the conductor splices and taps

i. **Knockout (KO)**—Partially cut out piece of metal or plastic that can be forced out when a hole is needed

j. **NEMA enclosures**—Electrical enclosures specially designed to standards for use in specific locations and for various conditions such as indoor, outdoor, dusty, corrosive, wet, and explosive conditions

k. **Outlet boxes**—Electrical boxes designed for the mounting of receptacles, switches, light fixtures, or other devices

l. **Rainproof**—So constructed, protected, or treated as to prevent rain from interfering with successful operation

m. **Raintight**—So constructed or protected that exposure to a beating rain will not result in the entrance of water

Objective 2

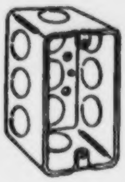
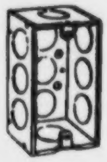
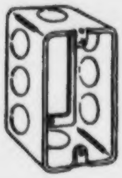
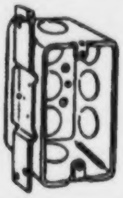
Classes of outlet boxes used in electrical wiring (*NEC* Article 370)

a. Outlet boxes (device boxes)

Note: Most boxes can be purchased in metal or in a nonmetallic composition such as fiber, plastic, nylon, or rubber.

- Handy boxes

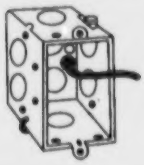
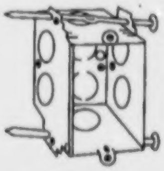
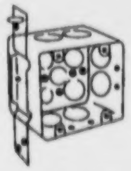
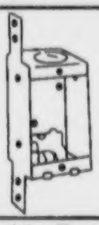
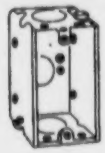
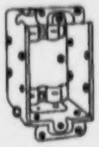
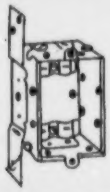
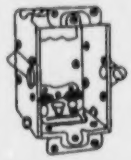
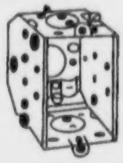
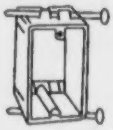
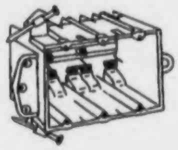
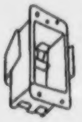
Figure 1

One-Piece Molded Construction	One-Piece Welded Construction
	
Extension	Box with Bracket
	

- Switch boxes

Note: Switch boxes ar available in steel, plastic, and Bakelite®.

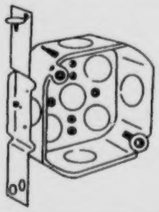
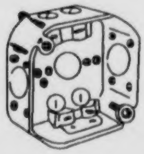
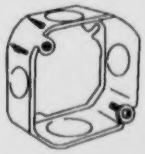
Figure 2

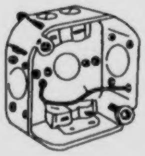
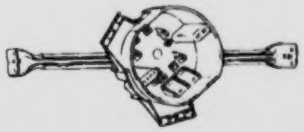
Gangable with Grounding Pigtail	Nail-On	Solid Two-Gang Bracket
		
Nongangable Bracket with Cable Clamps	Gangable with Nail Holes	Gangable with Ears and Cable Clamps
		
Gangable Bracket with Cable Clamps	Box with Drywall Grips, Cable Clamps, and Ears	Beveled Corner with Clamps and Ears
		
Non-Metallic Single Gang with Captive Nails	Non-Metallic Three Gang with Captive Nails	Single Gang Fiber Cut-In Box
		

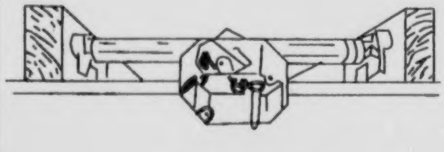
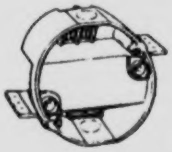
b. Octagon boxes

Note: Octagon boxes, like switch boxes, can be either metallic or nonmetallic; like switch boxes, they can be purchased in many different depths.

Figure 3

Box with Bracket	Box with Cable Clamps and Nail Holes	Extension
		

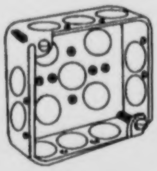
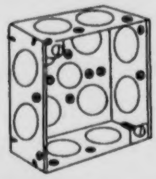
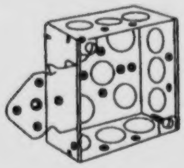
Box with Cable Clamps and Grounding Pigtail	Box with Bar Hanger and Cable Clamps
	

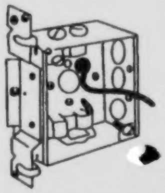
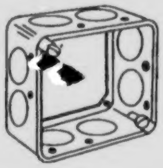
Metal Fan Hanger Box	Non-Metallic Fan Box
	

c. Square boxes

Note: Square boxes are used in conjunction with covers designed for special purposes.

Figure 4

One-Piece Molded Construction	One-Piece Welded Construction	Box with Bracket
		

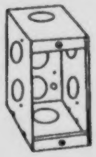
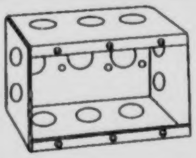
Box with Bracket, Cable Clamps, and Grounding Pigtail	Extension
	

d. Masonry boxes

Note: Masonry boxes have square corners that are easier to cut and save installation time. The boxes are deep so that conduit will position in the voids.

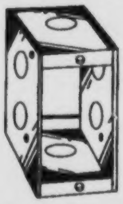
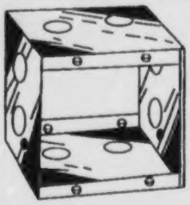
- Regular masonry boxes

Figure 5

Single-Gang	Three-Gang
	

- Masonry through-the-wall boxes

Figure 6

Single-Gang	Two-Gang
	

Objective 3

Information needed to calculate boxfill

a. Cubic inches of box

Note: Multiplying width times height times depth gives cubic inches.

b. Size of wire

c. Number of yoke- or strap-holding devices and grounds

Objective 4

Types of enclosures and their conditions for use

a. **General duty**—For normal use in locations without excessive dust, moisture, or corrosive atmospheres

b. **Dustproof**—For use where dust could interfere with normal operation

Examples: Feed mill, cement plant

c. **Weatherproof**—For use where rain or dust could interfere with normal operation

Examples: Irrigation motor controller

d. **Watertight**—For use in wet locations

Examples: Milk plant, mines

e. **Corrosionproof**—For use in locations having corrosive atmospheres (***NEC* Article 300-6)**

Examples: Galvanizing plant, fertilizer plant

f. **Explosionproof**—For use in hazardous locations (***NEC* Article 500)**

Examples: Grain elevators, oil refineries, chemical plants

Objective 5

Purposes of controller enclosures

a. Keeping boxes and enclosures clean

Note: Relays and contractors should be cleaned periodically to ensure continued operation.

b. Keeping boxes and enclosures dry

Note: Moisture is one of the greatest enemies of electrical insulation. Moisture due to condensation may collect inside a sealed enclosure. Heaters are often used to correct this condition.

c. Protecting boxes and enclosures from accidental contact

Caution: Never bring metal or other objects into contact with live parts.

d. Preventing injuries

Caution: To avoid personal injury, protective covers must be in place when system is in operation.

Objective 6

Types of devices commonly used in electrical wiring

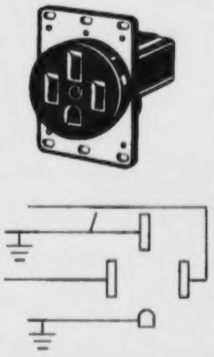
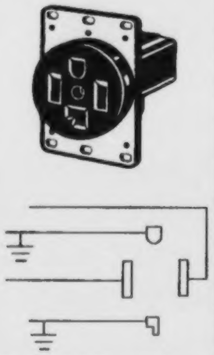
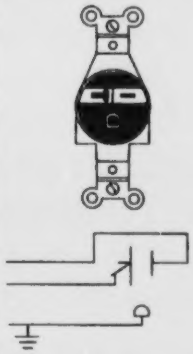
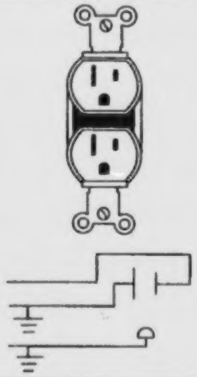
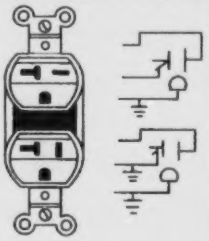
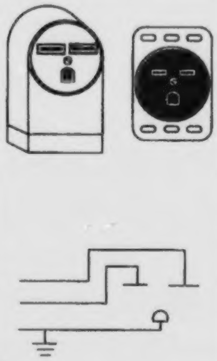
Note: Manufacturers make different grades of devices. Price and quality vary with the grades. Specification grade is the most expensive. Before installing devices, check the grade requested in the job bid.

a. Receptacles

Note: ***NEC* Articles 210, 220, and 410** deal with specific installation of receptacles.

Example: "**410-58(a)**. Grounding-type receptacles, cord connectors, and attachment plugs shall be provided with one fixed grounding pole in addition to the circuit poles."

Figure 7

125/250 V, 50 A	125/250 V, 30 A	25- V. 20 A
		
Duplex Grounding 125 V, 15 A	Dual Voltage 125/250 V, 20 A	250 V, 30 A
		

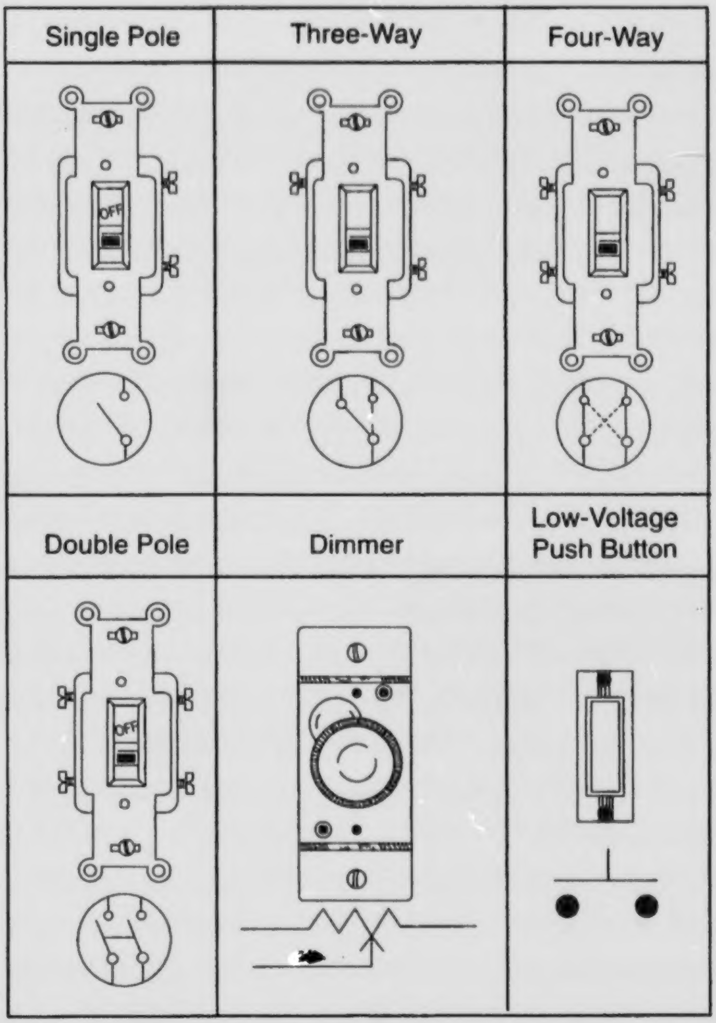
b. Switches

Note: **Article380 of the *NEC* covers switches.**

Example: "**380-2.** Three-way and four-way switches shall be so wired that all switching is done only in the ungrounded circuit conductor. Where in metal raceways or metal-armored cables, wiring between switches and outlets shall be in accordance with Section 300-20(a)."

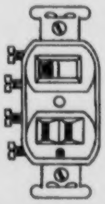
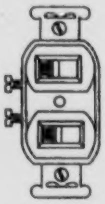
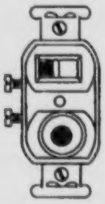
Exception: Switch loops shall not require a grounded conductor.

Figure 8


Single Pole
Three-Way
Four-Way
OFF
Double Pole
Dimmer
Low-Voltage Push Button
OFF

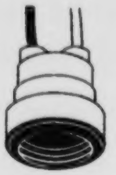
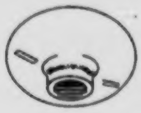
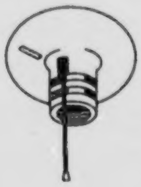
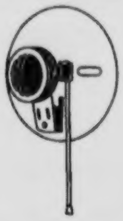
c. Combination devices

Figure 9

Switch and Receptacle	Two Switches	Switch and Pilot Light
		

d. Sockets

Figure 10

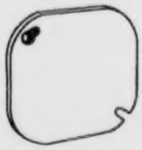
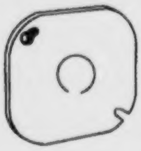
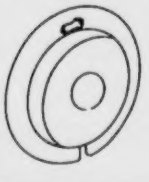
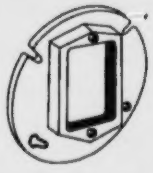
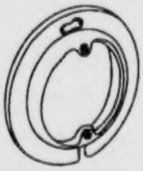
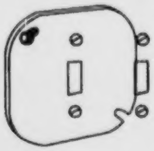
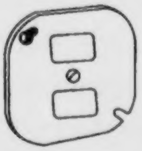
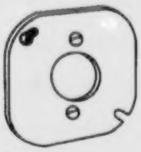
Keyless Pigtail	Keyless Cover
	
Pull-Chain Cover	**Pull-Chain Cover with Grounding Type Receptacle**
	

Objective 7

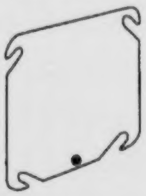
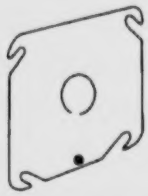
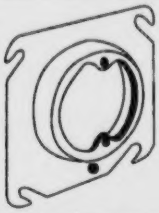
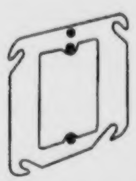
Types of covers and plates used in electrical wiring

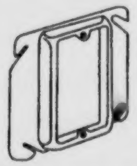
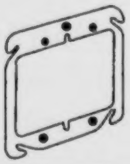
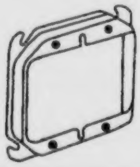
a. Round covers

Figure 11

Flat Blank	Flat Blank with Knockout	Raised with Knockout	Raised for Single Device
			
Raised Open	Flat Toggle	Flat Duplex Receptacle	Flat Single Receptacle
			

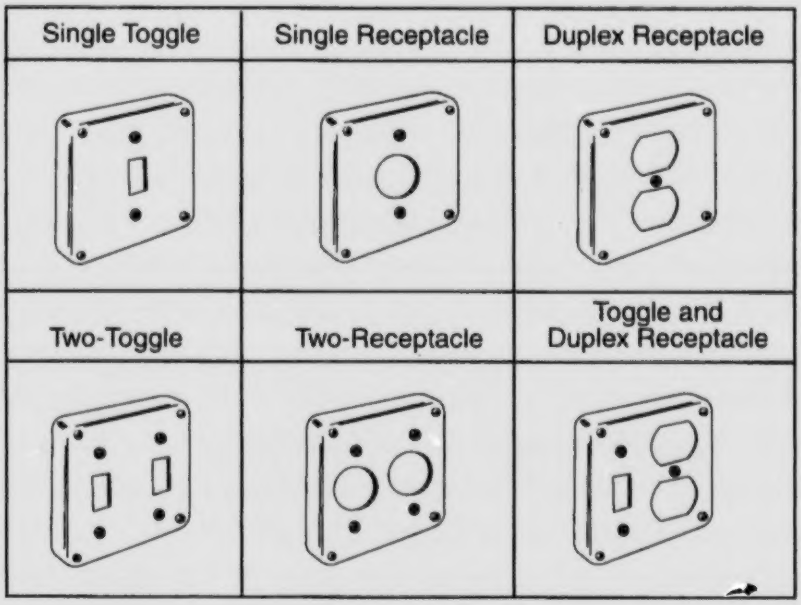
b. Square covers

Flat Blank	Flat Blank with Knockout	Raised Open	Flat for Single Device
			

Raised for Single Device	Flat for Two Devices	Raised for Two Devices
		

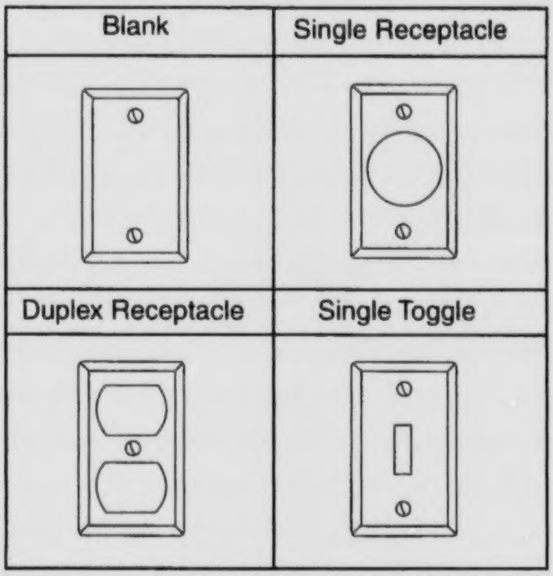
c. Exposed work raised square covers

Figure 12


Single Toggle
Single Receptacle
Duplex Receptacle
Two-Toggle
Two-Receptacle
Toggle and Duplex Receptacle

d. Handy box covers

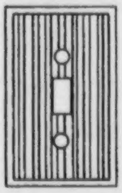
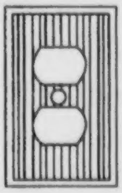
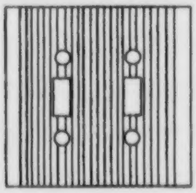
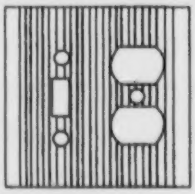
Figure 13

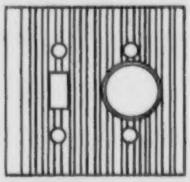
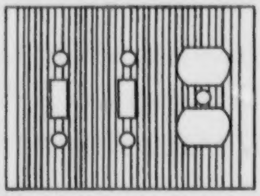
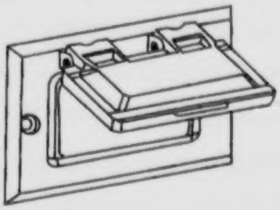
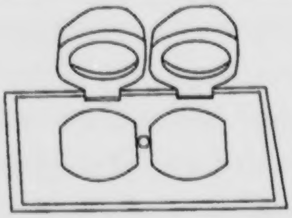
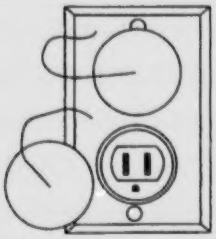
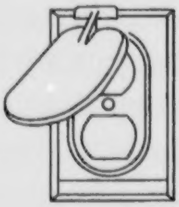

Blank
Single Receptacle
Duplex Receptacle
Single Toggle

e. Wall plates

Note: These are usually available in plastic or metal, but also come in decorator types for interior walls.

Figure 14

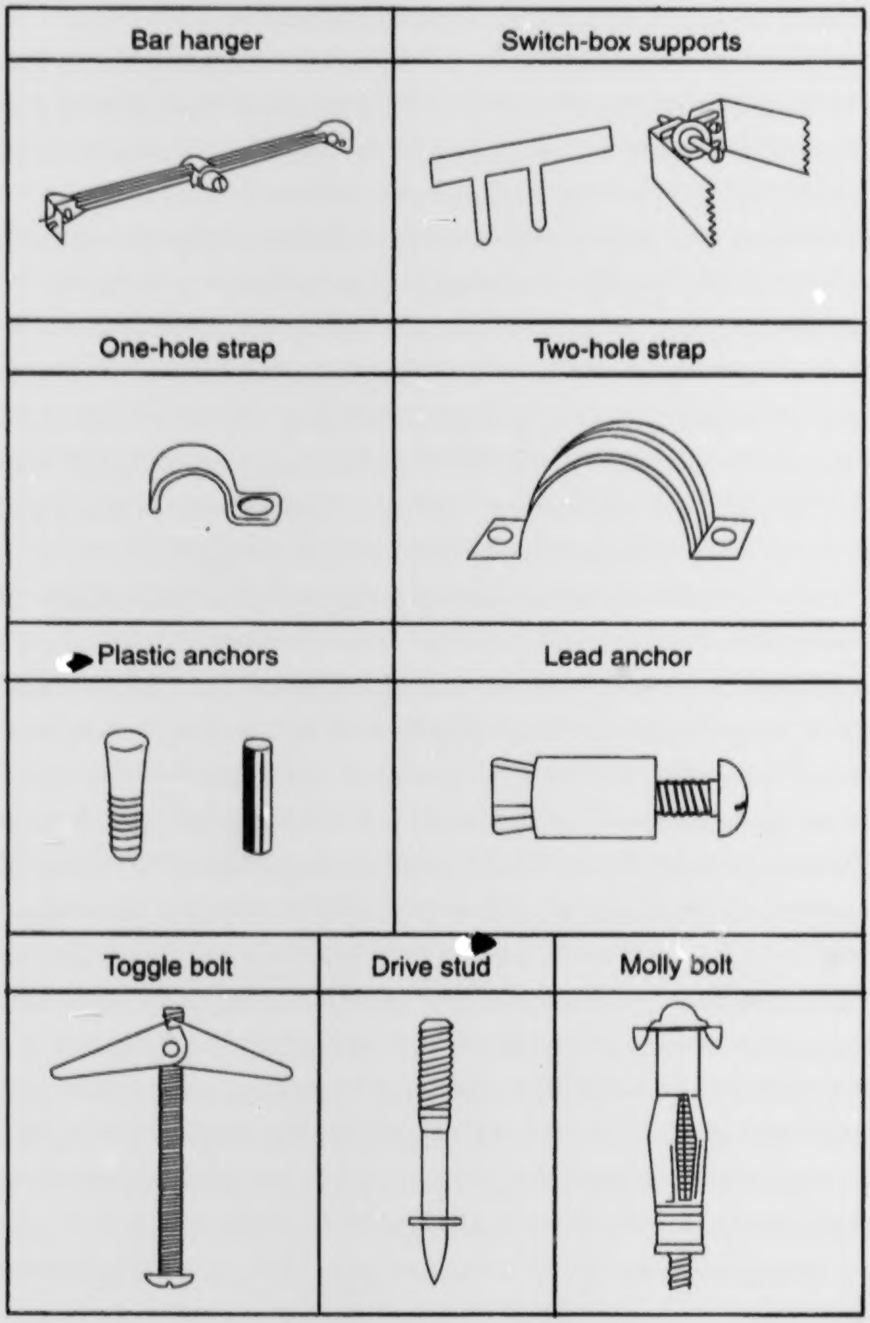
Single Toggle	Duplex Receptacle	Two-Toggle	Single Toggle and Duplex Receptacle
			

Single Toggle and Single Receptacle	Two-Toggle and Duplex Receptacle
	
Weatherproof GFCI Receptacle	Weatherproof Duplex Receptacle (Horizontal)
	
Weatherproof Duplex Receptacle with Screw Covers	Weatherproof Duplex Receptacle (Vertical)
	

Objective 8

Supports and anchors commonly used in electrical wiring

Figure 15

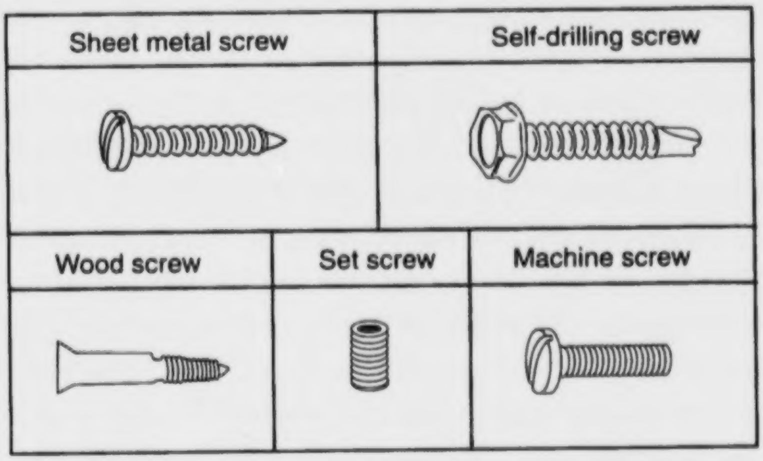

Bar hanger
Switch-box supports
One-hole strap
Two-hole strap
Plastic anchors
Lead anchor
Toggle bolt
Drive stud
Molly bolt

Objective 9

Screws, bolts, and nuts commonly used in electrical wiring

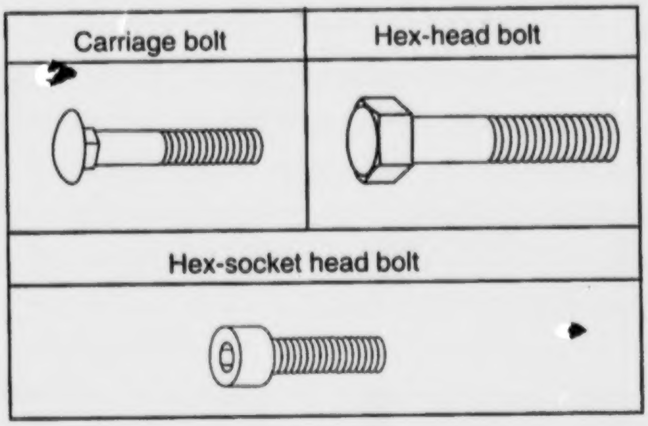
a. Screws

Figure 16


Sheet metal screw
Self-drilling screw
Wood screw
Set screw
Machine screw

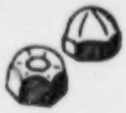
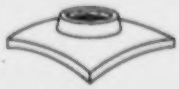
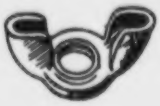
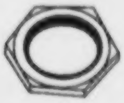
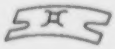
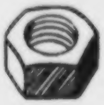
b. Bolts

Figure 17


Carriage bolt
Hex-head bolt
Hex-socket head bolt

c. Nuts

Figure 18

Acorn nut	Spring nut
	
Wing nut	Fixture nut
	
Single-thread nut	Plain hex nut
	

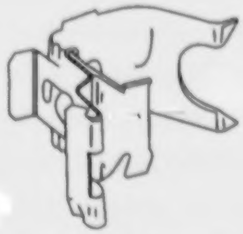
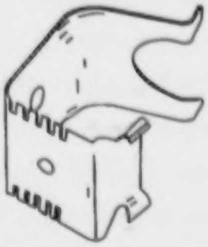
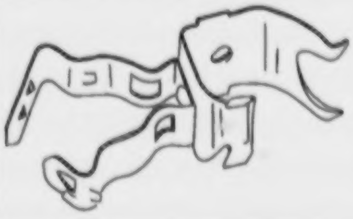
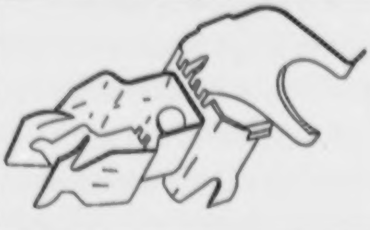
Objective 10

Classes of box-mounting devices for steel structures

a. Metal stud clips for switch boxes

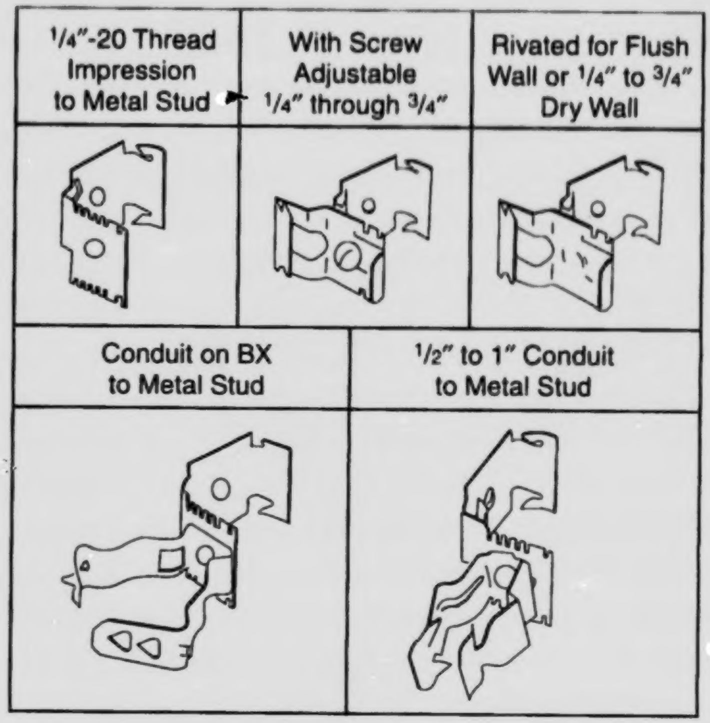
Note: Some types of metal stud supports may require extra screws to secure them to studs.

Figure 19

Riveted for Dry Wall, with Screw Adjustable 1/4" to 3/4"	1/4"-20 Thread Impression to Metal Stud
	
1/2" to 1" Conduit to Metal Stud	1/2" to 1" Conduit to Metal Stud
	

b. MF clips for switch boxes (metal stud fasteners)

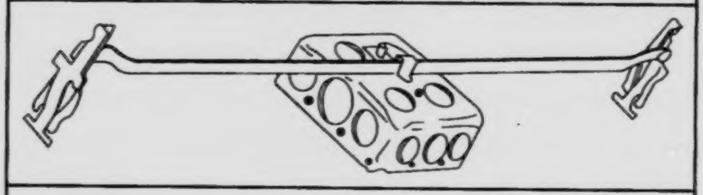
Figure 20


1/4"-20 Thread Impression to Metal Stud
With Screw Adjustable 1/4" through 3/4"
Rivated for Flush Wall or 1/4" to 3/4" Dry Wall
Conduit on BX to Metal Stud
1/2" to 1" Conduit to Metal Stud

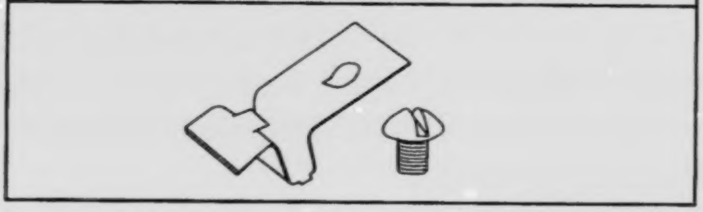
c. Acoustical tee-bar electrical box hanger and mounting clip

Figure 21

Acoustical "Tee-Bar" Electrical Box Hanger

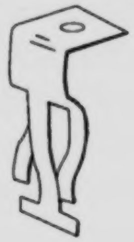
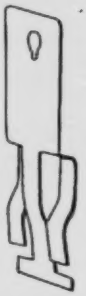
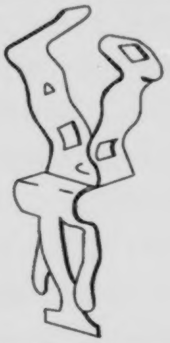
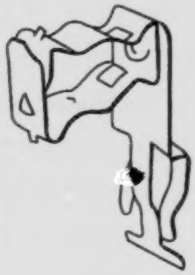
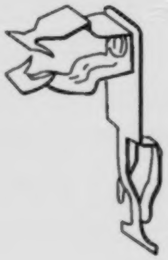
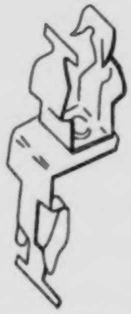


Mounting Clip



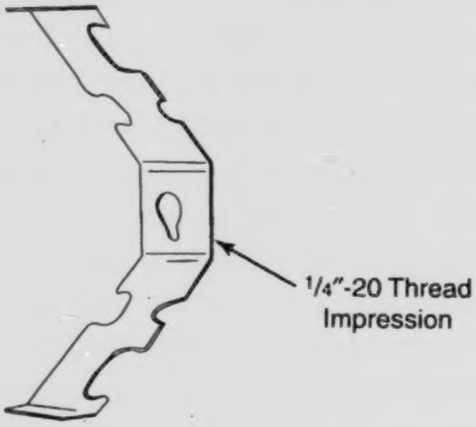
d. Acoustical tee-bar clips

Figure 22

Top-Mount with 1/4"-20 Thread Impression	Side-Mount with 1/4"-20 Thread Impression	Top-Mounted Conduit Clip for 3/8" or 1/2" to 3/4" Conduit
		
Wide Side-Mounted Condut Clip for 3/8" or 1/2" to 3/4" Conduit	With Side-Mounted Conduit Clip for 1/2", 3/4" or 1" Conduit	With Top-Mounted Conduit Clip for 1/2" or 3/4" Conduit
		

e. Conduit box clip

Figure 23


1/4"-20 Thread Impression

Unit 9 Basic Theory

Unit Contents

Student Components

Student Page

Learning Activities Sheet 9–3

Objective Sheet 9–5

Information Sheet 9–7

* Assignment Sheets

1—Draw a Diagram of the Power Distribution Supplying Your School Shop or Home 209
2—Solve Problems for Unknown Voltage 211
3—Solve Problems for Unknown Amperage 213
4—Solve Problems for Unknown Resistances and Wattages 215
5—Solve Problems for an Unknown Quantity 217

* Assignment Sheets are located in Student Workbook 1.

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet

☐ 3. **Study** Information Sheet, Objectives 1 and 2.

Optional

☐ 4. **View** Videotapes entitled "Basic Electricity" (Video 1) and "Small Sources of Electricity" (Video 4).

☐ 5. **Study** Information Sheet, Objectives 3 and 4.

☐ 6. **Do** Assignment Sheet 1, "Draw a Diagram of the Power Distribution Supplying Your School Shop or Home".

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 and 6.

☐ 8. **Study** Information Sheet, Objectives 5 thru 11.

☐ 9. **Do** Assignment Sheet 2, "Solve Problems for Unknown Voltage."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 8 and 9.

☐ 11. **Do** Assignment Sheet 3, "Solve Problems for Unknown Amperage."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat Steps 8 and 11.

Learning Activities Sheet

☐	13.	**Study**	Information Sheet, Objectives 12 thru 15.
☐	14.	**Do**	Assignment Sheet 4, "Solve Problems for Unknown Resistances and Wattages."
☐	15.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, repeat Steps 13 and 14.
☐	16.	**Do**	Assignment Sheet 5, "Solve Problems for an Unknown Quantity."
☐	17.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, repeat Steps 13 and 16.
☐	18.	**Check**	With instructor for any additional assignments to be completed.
☐	19.	**Take**	Posttest provided by instructor. After the test has been evaluated, follow instructor"s recommendations.
☐	20.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify electrical schematic symbols and apply Ohm's law formulas. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic electrical theory with their definitions.
2. Select true statements concerning the principles of electron flow.
3. Select words to complete statements concerning basic sources of electrical generation.
4. Complete statements concerning the distribution of electricity.
5. Match electrical schematic symbols with their names.
6. Distinguish between diagrams and schematics.
7. Select units of measure to complete definitions of electrical abbreviations.
8. State Ohm's law.
9. Draw Ohm's law in wheel expression.
10. List uses of Ohm's law.
11. State the unit of measure formulas from Ohm's law.
12. State Ohm's law for power.
13. Draw Ohm's law for power in wheel expression.
14. List uses of Ohm's law for power.
15. State the unit of measure formulas from Ohm's law for power.
16. Draw a diagram of the power distribution supplying your school shop or home. (Assignment Sheet 1)
17. Solve problems for unknown voltage. (Assignment Sheet 2)
18. Solve problems for unknown amperage. (Assignment Sheet 3)
19. Solve problems for unknown resistance and wattages. (Assignment Sheet 4)
20. Solve problems for an unknown quantity. (Assignment Sheet 5)

Information Sheet

Objective 1

Terms and definitions

a. **Amp (ampere)**—Unit of measure of the intensity of the electron flow in a circuit

b. **Electricity**—Invisible energy

c. **Electron flow**—Electrons transferring from one atom to another

d. **Ohm**—Unit of measure of the opposition to electron flow in a circuit

e. **Volt**—Unit of measure of electromotive force or potential difference

f. **Watt**—Unit of measure of the power of an electrical circuit

Objective 2

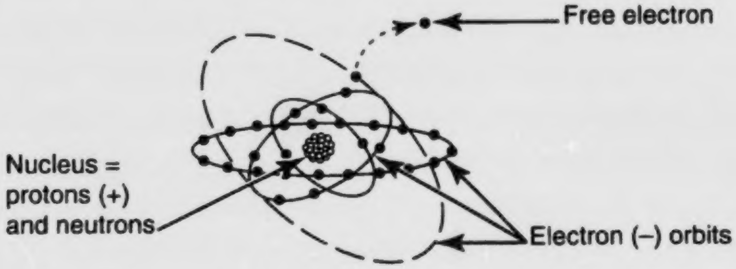
Principles of electron flow

a. Atoms contain both protons and electrons.

b. Protons always have a positive charge.

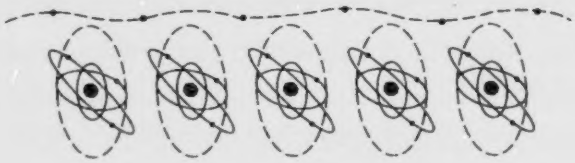
c. Electrons always have a negative charge.

Figure 1



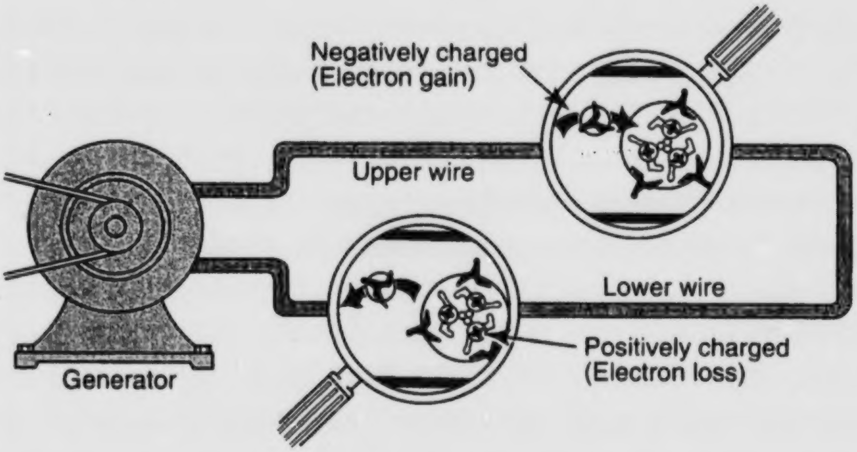
d. Electricity is the flow of one electron to another.

Figure 2



e. Generation occurs when an outside force of power excites the electron flow and electricity is produced.

Figure 3



Courtesy of AAVIM

Objective 3

Basic sources of electrical generation

a. **Friction** produces electricity when two materials are rubbed together.

Note: This type of electrical generation produces static electricity.

Example: When you slide your feet across a nylon or wool carpet your shoes develop a charge that is transferred to the body.

b. **Pressure** produces electricity when pressure is applied to crystalline substances such as quartz or tourmaline.

Example A crystal microphone or in a phono cartridge on the pickup arm of a record player.

c. **Heat** produces electricity when it is applied to the junction of two dissimilar metals.

Example: Thermocouple used in water heater.

d. **Light** produces electricity when it strikes a photosensitive material.

Example: Solar cell used on spacecraft

e. **Chemical action** produces electricity when that action takes place between two metals in a cell.

Example: Automobile and flashlight batteries

f. **Magnetism** produces electricity when a magnet is moved past a piece of wire.

Example: Generator in a power plant or automobile

Objective 4

Distribution of electricity

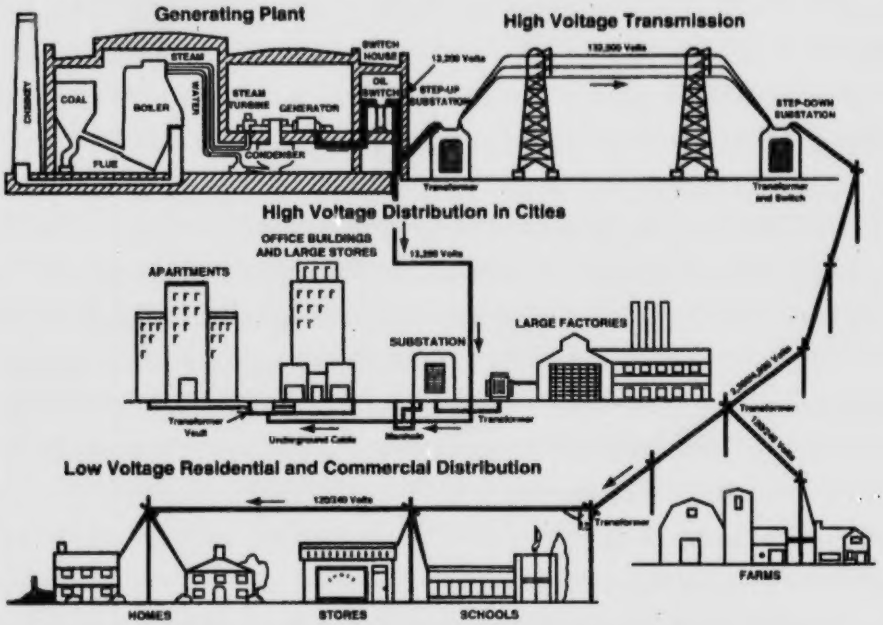
a. Power is produced at the generating plant.

b. Voltage is stepped up for high-voltage transmission.

c. Voltage is moved from one area to another through high-voltage transmission lines.

d. Voltage is stepped down and moved through transformers for public use.

Figure 4


Generating Plant
High Voltage Transmission
CHIMNEY
COAL
BOILER
STEAM
WATER
STEAM TURBINE
GENERATOR
FLUE
CONDENSER
SWITCH HOUSE
OIL SWITCH
13,200 Volts
STEP-UP SUBSTATION
132,000 Volts
Transformer
STEP-DOWN SUBSTATION
Transformer and Switch
High Voltage Distribution in Cities
OFFICE BUILDINGS AND LARGE STORES
13,200 Volts
APARTMENTS
SUBSTATION
LARGE FACTORIES
2,300/4,000 Volts
Transformer
120/240 Volts
Transformer Vault
Underground Cable
Manhole
Transformer
Low Voltage Residential and Commercial Distribution
120/240 Volts
Transformer
HOMES
STORES
SCHOOLS
FARMS

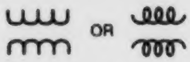
Reprinted with permission of Bennett Publishing Company. *Industrial Electricity* by Rex Miller.

Objective 5

Electrical schematic symbols

a. Transformer

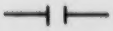
Figure 5



b. Contacts

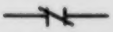
- Normally open

  Figure 6



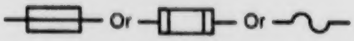
- Normally closed

  Figure 7



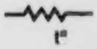
c. Fuse

Figure 8



d. Thermal resistor

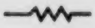
Figure 9



e. Resistor or load

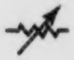
- Fixed

  Figure 10



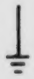
- Variable

  Figure 11



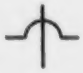
f. Ground connection

Figure 12



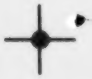
g. Wire crossover

Figure 13



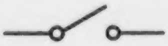
h. Wire connection

Figure 14



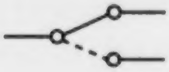
i. Single-pole, single-throw switch

Figure 15



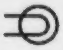
j. Three-way switch

Figure 16



k. Incandescent lamp

Figure 17



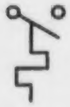
l. Alternating current motor

Figure 18

m. Temperature-activated switch

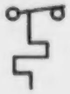
- Closes on rise

  Figure 19



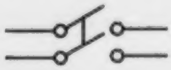
- Opens on rise

  Figure 20



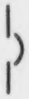
n. Double-pole, single-throw switch

Figure 21



o. Circuit breaker

Figure 22



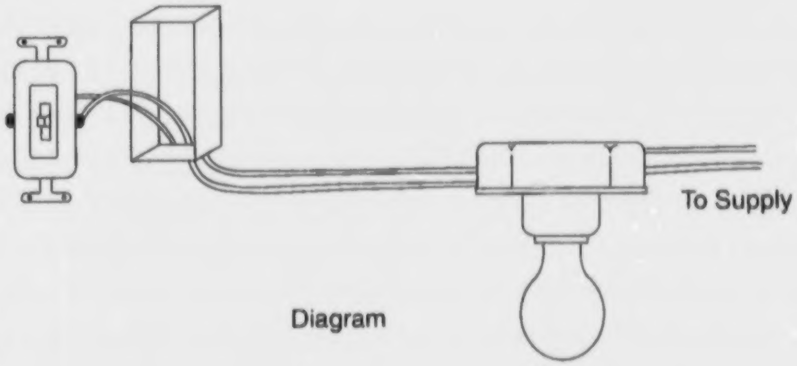
Objective 6

Diagrams and schematics

a. Diagram

- Drawing-type illustration
- Illustration is of actual equipment and device(s)

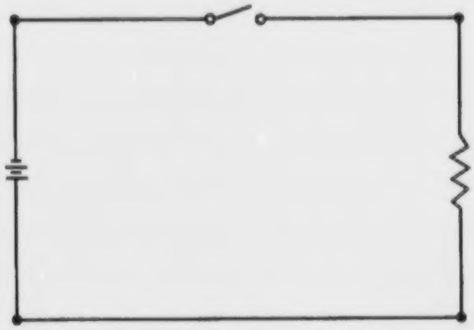
Figure 23



b. Schematic

- Line-type illustration
- Uses standard schematic symbols for equipment and device(s)

Figure 24

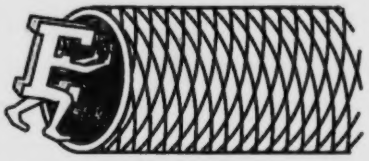


Objective 7

Definitions of electrical abbreviations

a. E—Electromotive force (Emf) in volts

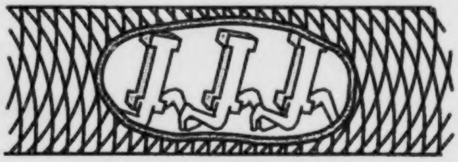
Figure 25



Voltage is pressure, or electromotive force.

b. I—Intensity in amps

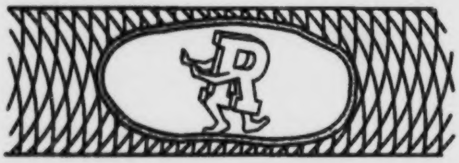
Figure 26



Current is the rate or flow of electrons

c. R—Resistance in ohms

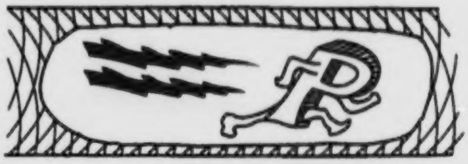
Figure 27



Resistance is opposition to current flow.

d. P—Power in watts

Figure 28



Combining volts and amperes produces a measurement of power.

Objective 8

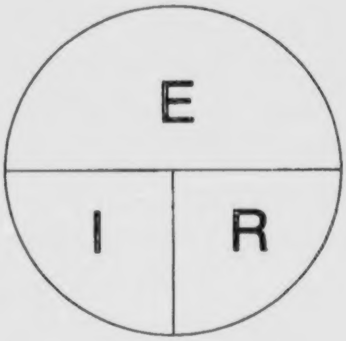
Ohm's law—The current in an electric circuit equals the pressure (volts) divided by the resistance

Note: It takes 1 volt to push 1 amp through 1 ohm of resistance.

Objective 9

Ohm's law in wheel expression

Figure 29



I = Amps
R = Ohms
E = Volts

Objective 10

Uses of Ohm's law

a. Calculating circuit resistance

b. Calculating circuit amperage

c. Calculating circuit voltage

Objective 11

Formulas from Ohm's law

Note: When you cover the unknown in the wheel representation of Ohm's law, the remaining letters give you the problem solving equation.

Figure 30: Volts = Amps x Ohms or E = I x R

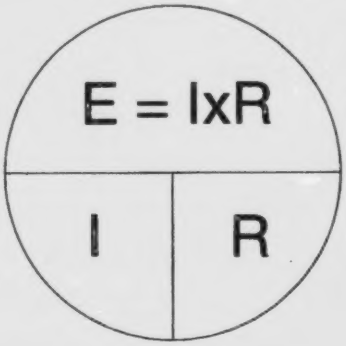


Figure 31: Amps = Volts ÷ Ohms or I = E/R

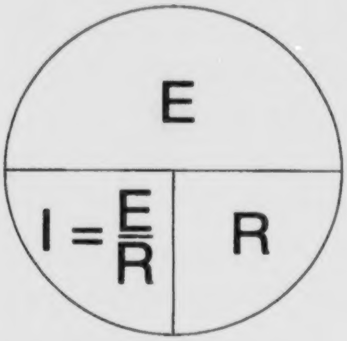
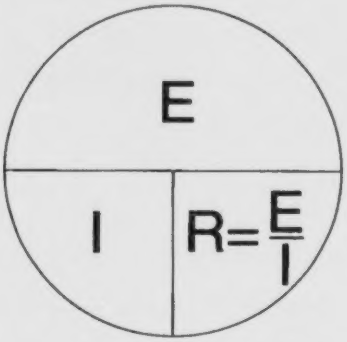


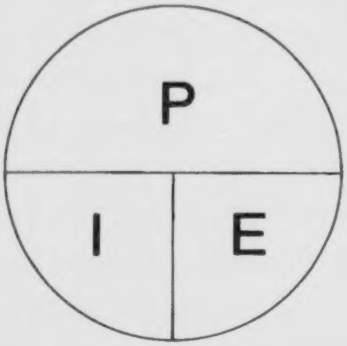
Figure 32: Ohms = Volts ÷ Amps or R = E/I



Objective 12 **Ohm's law for power**—The power in an electrical circuit equals the current (amperes) multiplied by the electromotive force (volts).

Objective 13 **Ohm's law for power in wheel expression**

Figure 33



P = Watts
I = Amps
E = Volts

Objective 14

Uses of Ohm's law for power

a. Calculating circuit wattage

b. Calculating circuit voltage

c. Calculating circuit amperage

Objective 15

Formulas from Ohm's law for power

Figure 34: Watts = Amps x Volts or P = I x E

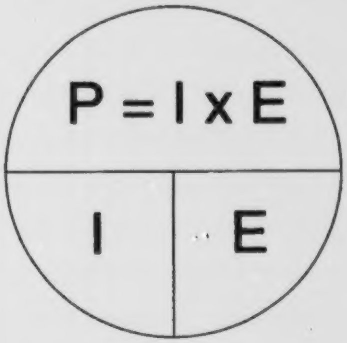


Figure 35: Amps = Watts ÷ Volts or I = P/E

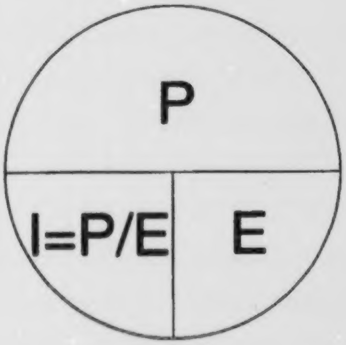
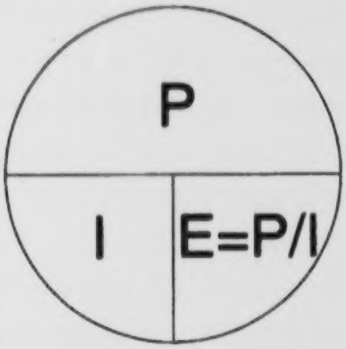


Figure 36: Volts = Watts ÷ Amps or E = P/I



Unit 10 DC Circuits

Unit Contents

Student Components

Student Page

Learning Activities Sheet 10–3
Objective Sheet 10–7
Information Sheet 10–9

Student Supplements

1—Facts About Magnetism 10–21

* Assignment Sheets

1—Solve Problems for Unknown Current 1
2—Solve Problems for Unknown Resistance 3
3—Solve Problems for Unknown Voltage 5
4—Determine Total Resistance in Series Circuits 7
5—Determine Unknown Resistance Values in Series Circuits 9
6—Solve Problems for Unknown Current in Series Circuits 11
7—Solve Problems for Unknown Resistance in Series Circuits 13
8—Solve Problems for Unknown Voltage in Series Circuits 15
9—Apply Kirchoff's Voltage Law to Series Circuits 17
10—Solve Problems for Unknown Resistance in Parallel Circuits 19
11—Solve Problems for Unknown Current in Parallel Circuits 21
12—Apply Kirchoff's Current Law to Parallel Circuits 23
13—Solve Problems for Unknown Resistance in Series-Parallel Circuits 25
14—Solve Problems for Unknown Voltage in Series-Parallel Circuits 27
15—Solve Problems for Unknown Current in Series-Parallel Circuits 29
16—Compute Power Using Ohm's Law 31

* Assignment Sheets are located in Student Workbook 2.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 3.

☐ 4. **Do** Assignment Sheet 1, "Solve Problems for Unknown Current."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat Steps 3 and 4.

☐ 6. **Do** Assignment Sheet 2, "Solve Problems for Unknown Resistance."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 3 and 6.

☐ 8. **Do** Assignment Sheet 3, "Solve Problems for Unknown Voltage."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat Steps 3 and 8.

Optional

☐ 10. **View** Videotape entitled "Series and Parallel Circuits."

Optional

☐ 11. **View** Videotape entitled "Combination Circuits."

☐ 12. **Study** Information Sheet, Objective 4.

Learning Activities Sheet

☐ 13. **Do** Assignment Sheet 4, "Determine Total Resistance in Series Circuits."

☐ 14. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, repeat Steps 12 and 13.

☐ 15. **Do** Assignment Sheet 5, "Determine Unknown Resistor Values in Series Circuits."

☐ 16. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat Steps 12 and 15.

☐ 17. **Do** Assignment Sheet 6, "Solve Problems for Unknown Current in Series Circuits."

☐ 18. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, repeat Steps 12 and 17.

☐ 19. **Do** Assignment Sheet 7, "Solve Problems for Unknown Resistance in Series Circuits."

☐ 20. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 21. If the evaluation is not satisfactory, repeat Steps 12 and 19.

☐ 21. **Do** Assignment Sheet 8, "Solve Problems for Unknown Voltage in Series Circuits."

☐ 22. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 23. If the evaluation is not satisfactory, repeat Steps 12 and 21.

☐ 23. **Study** Information Sheet, Objective 5 and 6.

☐ 24. **Do** Assignment Sheet 9, "Apply Kirchoff's Voltage Law to Series Circuits."

☐ 25. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 26. If the evaluation is not satisfactory, repeat Steps 23 and 24.

Optional

☐ 26. **View** Videotape entitled "Parallel Circuits."

☐ 27. **Study** Information Sheet, Objective 7.

☐ 28. **Do** Assignment Sheet 10, "Solve Problems for Unknown Resistors in Parallel Circuits."

☐ 29. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 30. If the evaluation is not satisfactory, repeat Steps 27 and 28.

☐ 30. **Do** Assignment Sheet 11, "Solve Problems for Unknown Current in Parallel Circuits."

☐ 31. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 32. If the evaluation is not satisfactory, repeat Steps 27 and 30.

☐ 32. **Study** Information Sheet, Objective 8.

☐ 33. **Do** Assignment Sheet 12, "Apply Kirchoff's Current Law to Parallel Circuits."

☐ 34. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 35. If the evaluation is not satisfactory, repeat Steps 32 and 33.

Optional

☐ 35. **View** Videotape entitled "Series/Parallel Circuits."

☐ 36. **Study** Information Sheet, Objective 9.

☐ 37. **Do** Assignment Sheet 13, "Solve Problems for Unknown Resistance in Series-Parallel Circuits."

☐ 38. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 39. If the evaluation is not satisfactory, repeat Steps 36 and 37.

Learning Activities Sheet

☐	39.	**Do**	Assignment Sheet 14, "Solve Problems for Unknown Voltage in Series-Parallel Circuits."
☐	40.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 41. If the evaluation is not satisfactory, repeat Steps 36 and 39.
☐	41.	**Do**	Assignment Sheet 15, "Solve Problems for Unknown Current in Series-Parallel Circuits."
☐	42.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 43. If the evaluation is not satisfactory, repeat Steps 36 and 41.
☐	43.	**Do**	Assignment Sheet 16, "Compute Power Using Ohm's Law."
☐	44.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 45. If the evaluation is not satisfactory, repeat Steps 36 and 43.
☐	45.	**Read**	Student Supplement 1, "Facts about Magnetism."
☐	46.	**Check**	With instructor for any additional assignments to be completed.
☐	47.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
☐	48.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to use Ohm's and Kirchoff's laws to solve problems for unknown current, rsistance, and voltage in DC circuits. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to DC circuits with their correct definitions.
2. List applications of DC circuits.
3. State the application of Ohm's law to direct current.
4. Select true statements about characteristics of series circuits.
5. Complete the three basic formulas for Watt's law.
6. State Kirchoff's voltage law.
7. Select true statements about characteristics of parallel circuits.
8. State Kirchoff's current law.
9. Complete statements about characteristics for series-parallel circuits.
10. Solve problems for unknown current. (Assignment Sheet 1)
11. Solve problems for unknown resistance. (Assignment Sheet 2)
12. Solve problems for unknown voltage. (Assignment Sheet 3)
13. Determine total resistance in series circuits. (Assignment Sheet 4)
14. Determine unknown resistor values in series circuits.(Assignment Sheet 5)
15. Solve problems for unknown current in series circuits. (Assignment Sheet 6)
16. Solve problems for unknown resistance in series circuits. (Assignment Sheet 7)
17. Solve problems for unknown voltage in series circuits. (Assignment Sheet 8)
18. Apply Kirchoff's voltage law to series circuits. (Assignment Sheet 9)
19. Solve problems for unknown resistance in parallel circuits. (Assignment Sheet 10)

Objective Sheet

20. Solve problems for unknown current in parallel circuits. (Assignment Sheet 11)

21. Apply Kirchoff's current law to parallel circuits. (Assignment Sheet 12)

22. Solve problems for unknown resistance in series-parallel circuits. (Assignment Sheet 13)

23. Solve problems for unknown voltage in series-parallel circuits. (Assignment Sheet 14)

24. Solve problems for unknown current in series-parallel circuits. (Assignment Sheet 15)

25. Compute power using Ohm's law. (Assignment Sheet 16)

Information Sheet

Objective 1

Terms and definitions

a. **Amperage (A)**—Electrical current flow; electron flow, must be measured at a point within a circuit

b. **Circuit**—A complete path for current to flow from the source through the load and back to the source

c. **Conductors**—Materials that permit the free flow of electrons

d. **Direct Current (DC)**—An electrical current flowing in one direction only and substantially constant in value

e. **Domains**—Molecules that act as small magnets when arranged end to end

f. **Electromagnet**—A magnet made by winding a conductor around a metal core with voltage applied

g. **Flux lines**—Power around a magnet

h. **Formula**—A mathematical expression used to find unknowns

i. **Magnetism**—Property of certain materials that exerts a mechanical force on other magnetic materials, and can cause induced voltage in conductors when relative movement is present

j. **Ohm(Ω)**—Unit of measure of the opposition to electron flow in a circuit

k. **Parallel circuit**—A circuit that provides more than one path for current flow

l. **Polarity**—When magnetism leaves a body north and enters south

Example: When using a VOM, the red lead always connects to the positive, and the black lead always connects to the negative.

m. **Power**—Rate of consumption of energy

n. **Resistance** (R)—Opposition to electron flow in a conductor or circuit

Note: Electron flow in a circuit always travels from positive to negative.

o. **Resistor** (—∧∨∧∨—)—Device which opposes the flow of electrical energy

p. **Series circuit**—A circuit that provides only one path for current flow

q. **Series-parallel circuit**—A circuit that contains some components in series and some in parallel

r. **Voltage**—The measurement of the potential difference between conductors in a circuit

s. **Voltage drop**—Reduction in circuit potential difference due to resistance

Objective 2

Applications of DC circuits

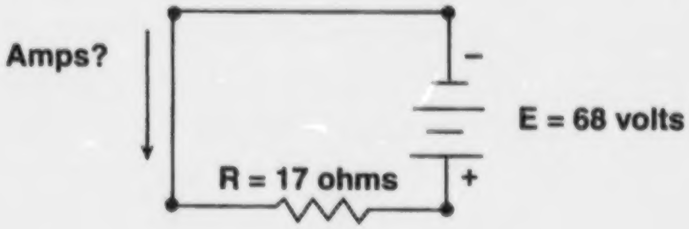
- a. Industrial locations for controls and power
- b. Moving of materials and parts
- c. Home appliances, radio, television, and stereo equipment
- d. Automobile and truck systems
- e. Telephone and communications circuits
- f. Computers and electronic equipment
- g. Airplane control and power systems
- h. Medical field
- i. Power for electric carts and battery charges

Objective 3

Applications of Ohm's law to DC (Figures 1-3)

a. **Ohm's law for computing current (I)** — $I = E/R$

Figure 1



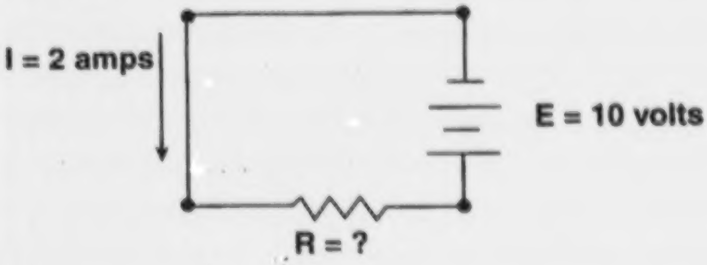
$$I = \frac{E}{R}$$

$$= \frac{68V}{17\Omega}$$

$$= 4A$$

b. **Ohm's law for computing resistance (R)** — R = E/I

Figure 2


I = 2 amps
E = 10 volts
R = ?

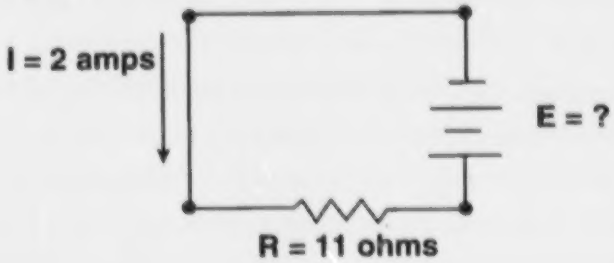
$$R = \frac{E}{I}$$

$$= \frac{10V}{2A}$$

$$= 5\Omega$$

c. **Ohm's law for computing voltage (E)** — E = I x R

Figure 3


I = 2 amps
E = ?
R = 11 ohms

$E = I \times R$

$= 2A \times 11\Omega$

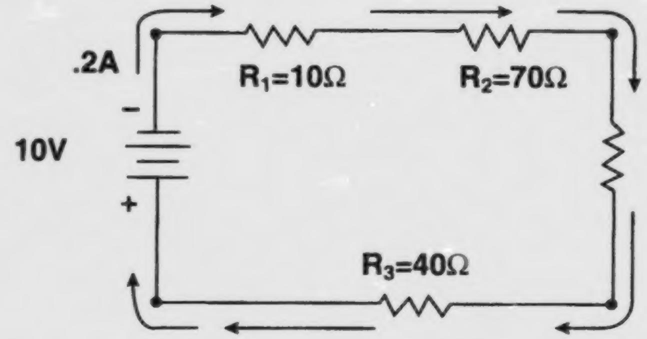
$= 22V$

Objective 4

Characteristics of series circuits (Figures 4-7)

a. Current in a series circuit flows only one way through components connected end-to-end, forming a continuous loop and returning to the power source.

Figure 4



Note: When voltage and current are known, the total resistance in a series circuit can be calculated using Ohm's law.

$$R = \frac{E}{I}$$

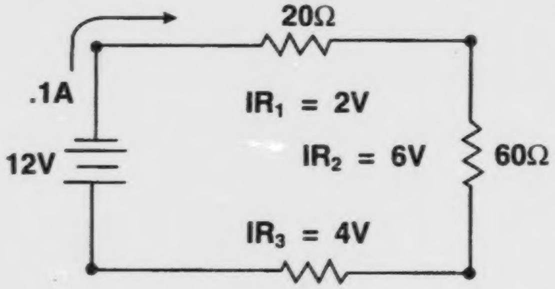
$$= \frac{10V}{.2A}$$

$$= 120\Omega$$

b. Should an open occur in any circuit component, current stops flowing through the circuit and to all loads.

c. When current travels through a resistor, the voltage drop across each resistor is equal to the current times the resistance (E = I x R).

Figure 5



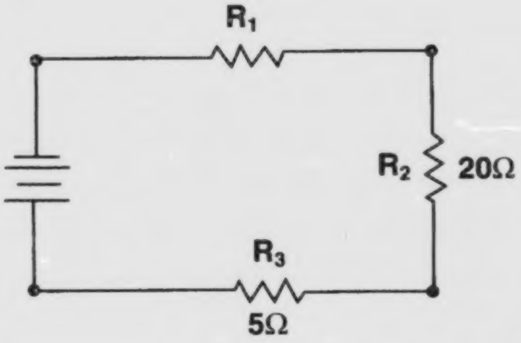
I_{R_1} = .1A x 20Ω = 2V

I_{R_2} = .1A x 60Ω = 6V

I_{R_3} = .1A x 40Ω = 4V

d. In a series circuit, the formula ($R_1 = R_t - R_2 - R_3$) may be used to find an individual resistance if the total resistance and the resistances of the other components are known.

Figure 6



$R_t = 50\Omega$

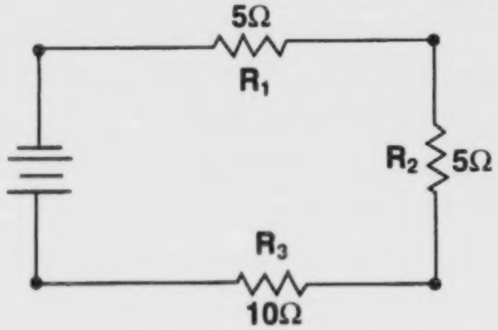
$R_1 = R_t - R_2 - R_3$

$= 50\Omega - 20\Omega - 5\Omega$

$= 25\Omega$

e. When totaling resistance in a series circuit, the sum of each resistance in the circuit can be mathematically stated ($R_t = R_1 + R_2 + R_3$).

Figure 7



$R_t = R_1 + R_2 + R_3$

$= 5\Omega + 5\Omega + 10\Omega$

$= 20\Omega$

Objective 5

Watt's law—Power in an electrical circuit may be calculated by using this law, which is expressed by three basic formulas:

a. P (in watts) = E (volts) x I (amperes)

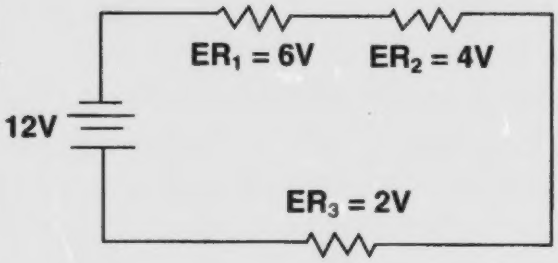
b. P (in watts) = I^2 (amperes) x R (ohms)

c. $P \text{ (in watts)} = \frac{E^2 \text{ (volts)}}{R \text{ (ohms)}}$

Objective 6

Kirchoff's voltage law—The sum of the individual voltage drops in a series circuit is equal to the applied voltage. (Figure 8)

Figure 8



The individual voltage drops are 6 volts, 4 volts, and 2 volts.

$E_t = 12V$

$E_t = E_{R_1} + E_{R_2} + E_{R_3}$

$= 6V + 4V + 2V$

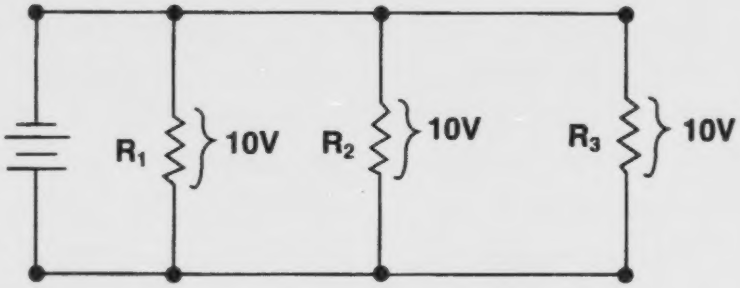
$= 12V$

Objective 7

Characteristics of parallel circuits (Figures 9-12)

a. Current in a parallel circuit travels in more than one path through two or more loads connected across two lines; voltage remains constant throughout the circuit.

Figure 9



b. Should an open occur in any one path, current stops flowing through that path, and to the load on that path, but continues flowing through other paths and to their loads.

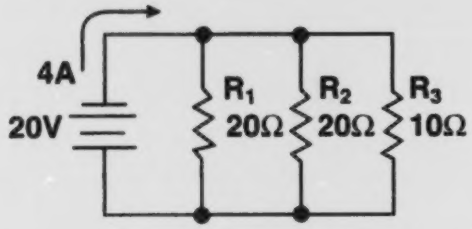
c. Voltage drop in a parallel circuit is the drop over the entire circuit. The voltage remains the same throughout the entire system.

d. Total resistance in a parallel circuit is always less than any branch resistance. Ohm's law is used to calculate total resistance.

Note: When total current and total voltage are given, total resistance may be calculated as shown in the example.

Example $R = \frac{E}{I}$

Figure 10



$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{20} + \frac{1}{20} + \frac{1}{10}$$

$$= \frac{1}{20} + \frac{1}{20} + \frac{2}{20}$$

$$= \frac{4}{20}$$

$$= 5\Omega$$

e. Reciprocals are used in figuring resistance. Reciprocals are any fraction turned upside down.

Example: Reciprocal of 3 is $^1/_3$

Reciprocal of $^3/_4$ is $^4/_3$

Note: A scientific calculator may be used to simplify the solving of parallel resistance. The solution for the above problem is as follows on the next page.

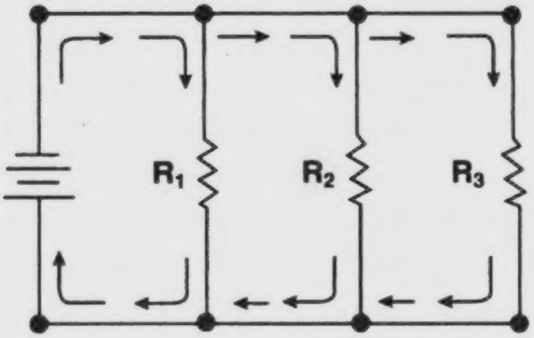
Solution

	Keystroke	*Display*
Enter R_1	2 0	20
Reciprocal	1/X	.05
Store in Memory	STO	.05
Enter R_2	2 0	20
Reciprocal	1/X	.05
Add to Memory	SUM	.05
Enter R_3	1 0	10
Reciprocal	1/X	.10
Add to Memory	SUM	.10
Recall the contents of the Memory, which is the sum of the three reciprocals.	RCL	.20
Find reciprocal of the sum (ohms).	1/X	5

Not all scientific calculators will require the same keystrokes. Check your calculator's users' manual for the proper keystrokes.
(See your instructor for assistance.)

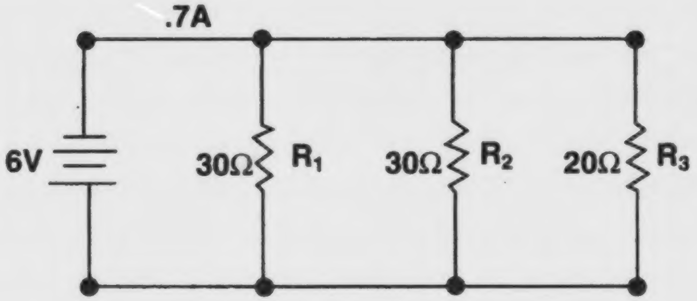
f. Parallel branch circuits differ from series circuits as there are many different paths for the current to follow.

Figure 11



g. When voltage and the resistance of each branch are known, the branch currents may be calculated by Ohm's law (I = E/R)

Figure 12



Calculations for R_1:

$I \frac{E}{R}$ $\quad I_{R_1} = \frac{E}{R_1}$ $\quad I_{R_1} = \frac{6V}{30\Omega}$ $\quad I_{R_1} = .2$ amps

Calculations for R_2:

$I_{R_2} = \frac{E}{R_2}$ $\quad I_{R_2} = \frac{6V}{30\Omega}$ $\quad I_{R_1} = .2$ amps

Calculations for R_3:

$I_{R_3} = \frac{E}{R_3}$ $\quad I_{R_3} = \frac{6V}{20\Omega}$ $\quad I_{R_1} = .3$ amps

h. The total of all three branch currents may now be put into a formula for total current.

Example: $I_t = .7A$

$$I_t = I_{R_1} + I_{R_2} + I_{R_3}$$

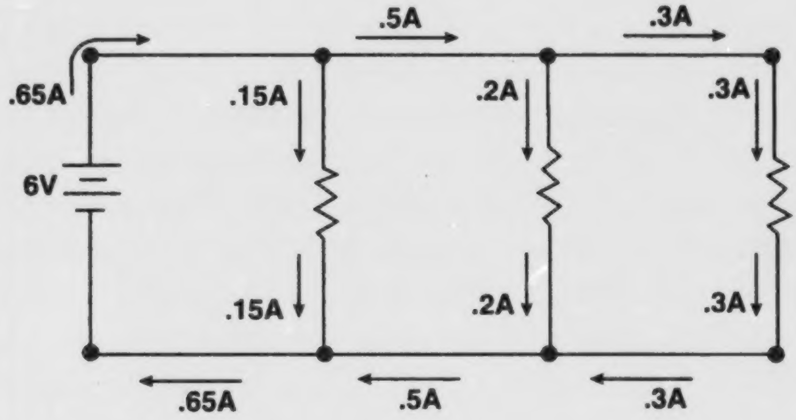
$$= .2A + .2A + .3A$$

$$= .7A$$

Objective 8

Kirchoff's current law—The sum of the currents through the individual branches of a parallel circuit is equal to the total current of the circuit.

Figure 13



$I_t = .65$

$$I_t = I_{R_1} + I_{R_2} + I_{R_3}$$

$$= .15A + .2A + .3A$$

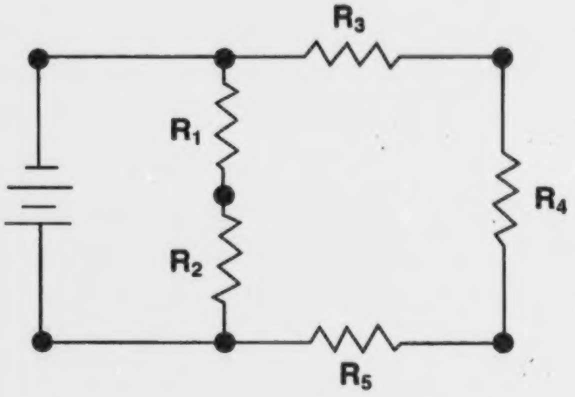
$$= .65A$$

Objective 9

Characteristics of series-parallel circuits (Figures 14-16)

a. A series-parallel circuit is a circuit used with both series circuits and parallel circuits connected.

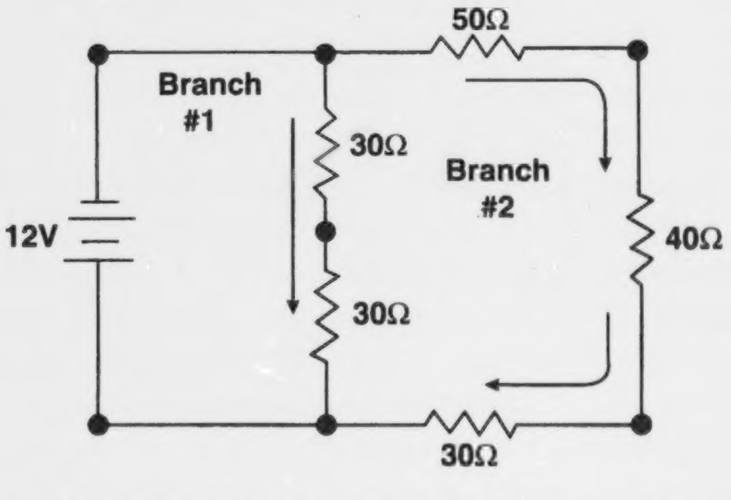
Figure 14



b. To find resistance in series-parallel circuits requires two steps.

Note: Series-parallel circuits must be simplified before the values can be calculated.

Figure 15



- Step 1: Calculate the total resistance for the circuit by adding together the series resistances in each branch. In circuit #1 the series resistances are 30Ω and 30Ω.

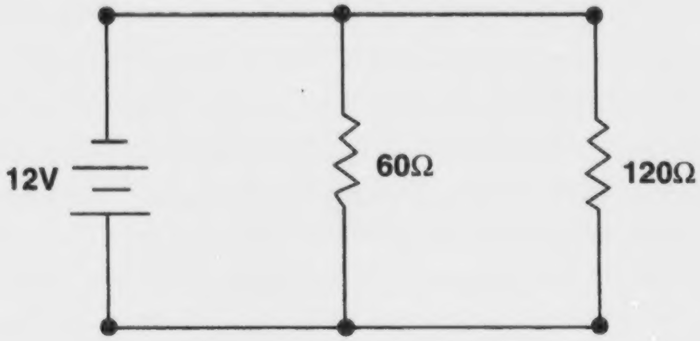
Formula: R branch #1 = 30Ω + 30Ω
R branch #1 = 60Ω

In circuit #2 the series resistances are 50Ω + 40Ω + 30Ω.

Formula: R branch #2 = 50Ω + 40Ω + 30Ω
R branch #2 = 120Ω

- Step 2: Redraw the circuit to use only one resistance in each branch.

Figure 16



- The resistance for the circuit may now be calculated by combining the parallel resistances.

Formula: $R_t = 40$

$$\frac{1}{R_t} = \frac{1}{R_{\text{branch \#1}}} + \frac{1}{R_{\text{branch \#2}}}$$

$$R_t = \frac{1}{R_{\text{branch \#1}}} + \frac{1}{R_{\text{branch \#2}}}$$

$$= \frac{2}{120} + \frac{1}{120}$$

$$= \frac{3}{120}$$

$$= \frac{1}{40}$$

$$= 40$$

Note: A scientific calculator may be used to simplify the solving of circuit resistance.

Student Supplement 1—Facts About Magnetism

a. There are two basic kinds of magnetism:

- Naturally magnetic minerals called lodestones,
- Electromagnets that are man-made from steel cores with wire windings and are produced by electricity.

b. Molecules, called domains, act as small magnets if properly arranged.

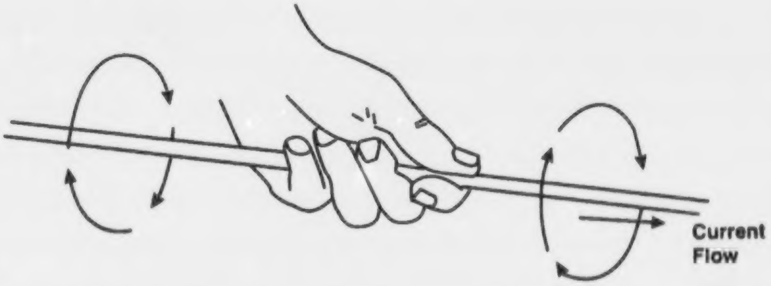
c. A magnet is composed of lines of power, called flux lines, around the magnetic field.

d. Magnetic flux lines have four magnetic fields.

- When the north pole is put to the south pole, they attract.
- When north pole and north pole are aligned, they repel.
- When south pole and south pole are aligned, they repel.
- Magnetic attraction varies with pole strength and distance.

e. Electromagnets are used for iron lifting, and opening contactors, valves, breakers, and relays.

f. The Left-Hand Rule for finding the direction of circulation of magnetic lines of flux states: If you grasp a straight wire with your left hand and point your thumb in the direction of electron flow (negative to positive), your fingers will curl in the direction of the magnetic flux.



Unit Contents

Student Components

Student Page

Learning Activities Sheet 11–3

Objective Sheet 11–7

Information Sheet 11–9

* Focus Assignment

List Facts About Producing Electricity 33

* Assignment Sheets

1—Solve RC and RL Circuit Problems 35
2—Solve Power Factor Problems 37
3—Draw a Diagram of a Single-Pole Switch on a Light 39
4—Draw a Diagram of Two-Three-Way Switches on a Light 41
5—Draw a Diagram of Two Three-Way Switches and a Four-Way Switch on a Light 43

* Job Sheets

1—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Switch Box 45
2—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box . . 55
3—Wire a Three-Way Switching Situation with the Supply Line Entering a Single Lighting Outlet 61
4—Wire a Four-Way Switching Situation with the Supply Line Entering the Lighting Outlet Box 69

* Focus Assignment, Assignment Sheets, and Job Sheets are located in Student Workbook 2.

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "List Facts About Producing AC Electricity."

Optional

☐ 4. **View** Videotapes entitled "Alternating Current" (Video 1) and "Series Circuits" (Video 4).

☐ 5. **Study** Information Sheet, Objectives 1 and 2.

Optional

☐ 6. **View** Videotapes entitled "Inductance" (Video 2) and "Capacitors" (Video 3).

☐ 7. **Study** Information Sheet, Objectives 3 through 16.

☐ 8. **Do** Assignment Sheet 1, "Solve RC and RL circuit Problems."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat Steps 7 and 8.

☐ 10. **Study** Information Sheet, Objective 17.

☐ 11. **Do** Assignment Sheet 2, "Solve Power Factor Problems."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to Step 13. If the evaluation is not satisfactory, repeat Steps 10 and 11.

☐ 13. **Study** Information Sheet, Objective 18.

Learning Activities Sheet

☐ 14. **Do** Assignment Sheet 3, "Draw a Diagram of Single-Pole Switch on a Light."

☐ 15. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to Step 16. If the evaluation is not satisfactory, repeat Steps 13 and 14.

☐ 16. **Do** Assignment Sheet 4, "Draw a Diagram of Two Three-Way Switches on a Light."

☐ 17. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to Step 18. If the evaluation is not satisfactory, repeat Steps 13 and 16.

☐ 18. **Do** Assignment Sheet 5, "Draw a Diagram of Two Three-Way Switches and a Four-Way Switch on a Light."

☐ 19. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to Step 20. If the evaluation is not satisfactory, repeat Steps 13 and 18.

☐ 20. **Do** Job Sheet 1, "Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering a Switch Box."

☐ 21. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 22. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 20.

☐ 22. **Do** Job Sheet 2, "Wire a Single Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box."

☐ 23. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 24. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 22.

☐ 24. **Do** Job Sheet 3, "Wire a Three-Way Switching Situation with the Supply Line Entering a Single Lighting Outlet."

☐ 25.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 26. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 24.
☐ 26.	**Do**	Job Sheet 4, "Wire a Four-Way Switching Situation with the Supply Line Entering the Lighting Outlet Box."
☐ 27.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 28. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 26.
☐ 28.	**Check**	With instructor for any additional assignments to be completed.
☐ 29.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
☐ 30.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to construct and wire single, three-way, and four-way switches in a circuit. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to AC circuits with their definitions.
2. Select true statements about the principles of AC theory.
3. Complete statements related to the principles of induction.
4. Complete statements about inductance characteristics.
5. Select true statements about factors affecting inductors.
6. Select true statements about power characteristics in inductive circuits.
7. Complete statements about transformer characteristics.
8. List two classes of transformers.
9. Identify single-phase transformer connections.
10. Identify other transformer connections found in electrical trades.
11. Complete statements about power in three-phase circuits.
12. Select true statements about testing for polarity.
13. Complete statements about capacitance characteristics.
14. Select true statements about types, ratings, and common defects of capacitors.
15. Complete statements about capacitive AC RC circuits.
16. Complete statements about inductive AC circuits.
17. Select true statements about power characteristics in AC circuits.
18. List three basic switching circuits used in electricity.
19. List facts about producing AC electricity (Focus Assignment)
20. Solve RC and RL circuit problems. (Assignment Sheet 1)

21. Solve power factor problems. (Assignment Sheet 2)

22. Draw a diagram of a single-pole switch on a light. (Assignment Sheet 3)

23. Draw a diagram of two three-way switches on a light. (Assignment Sheet 4)

24. Draw a diagram of two three-way switches and a four-way switch on a light. (Assignment Sheet 5)

25. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the switch box. (Job Sheet 1)

26. Wire a single-pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box. (Job Sheet 2)

27. Wire a three-way switching situation with the supply line entering a single lighting outlet. (Job Sheet 3)

28. Wire a four-way switching situation with the supply line entering the lighting outlet box. (Job Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Apparent power**—Term used to describe the power that "appears" to be consumed in an RC circuit when the power formula VA = IE is applied to the circuit

b. **Autotransformer**—Transformer with a single winding

c. **Connections**—Termination points where conductors are joined together

d. **Dielectric materials**—Insulating materials capable of accumulating an electrical charge

e. **Henry**—Amount of inductance into a conductor when the current changes at the rate of 1 ampere per second

f. **Opposition**—Resistance to current flow

g. **Primary**—Transformer winding that receives power from the source

h. **Secondary**—Transformer winding that receives power from the primary winding

i. **Single phase**—One AC power source

j. **Three phase**—Three separate AC power sources

k. **True power**—The power that a device is actually using

l. **Waveform**—The shape of a wave as a function of time, distance, and amplitude

m. **Windings**—Conductors coiled around a metal core in a transformer or motor

Information Sheet

Objective 2

Principles of AC theory

a. AC current flows in two directions; it flows in one direction, stops, and then flows in the opposite direction.

b. There are three basic types of waveforms: sine wave, square wave, and sawtooth wave.

Figure 1—Sine Wave

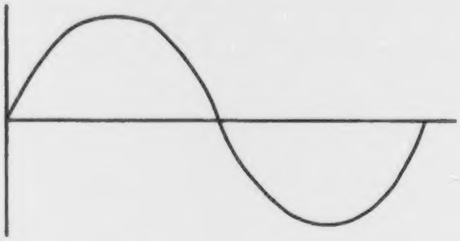


Figure 2—Square Wave

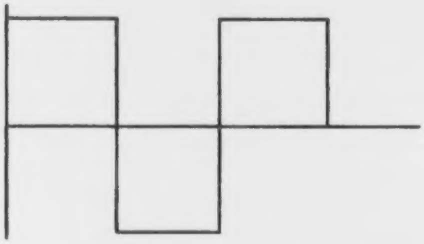
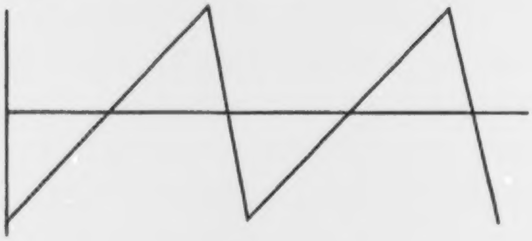
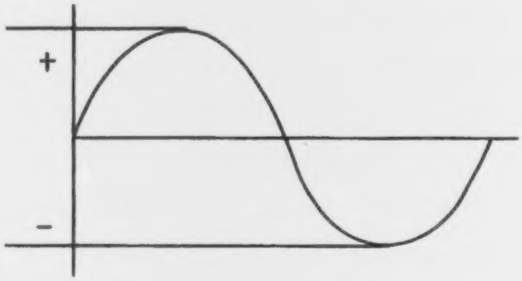


Figure 3—Sawtooth Wave



c. Sine waves are measured peak-to-peak in AC voltage or amperes.

Figure 4



d. Peak-to-peak current and voltages occur twice in a cycle; one in the positive direction and one in the negative direction.

e. The rms (root-mean-square) or effective value of the sine wave is 0.707 times peak value.

f. Electromotive force (emf) causes current to flow through a device; this is referred to in sine waves as V.

Objective 3

Principles of Induction

a. Magnetic induction occurs when a magnet is placed in close proximity to a ferromagnetic material causing the material to also become magnetized.

b. Electromagnetic induction is the action that causes electrons to flow in a conductor when the conductor cuts the lines of force in a magnetic field.

c. The amount of current induced into the conductor is determined by four factors (Faraday's law):

- **Strength** of the magnetic field
- **Speed** of the conductor with respect to the field
- **Angle** at which the conductor cuts the field
- **Length** of the conductor in the field

d. Lenz's law states that the direction of the induced current must be such that its own magnetic field will oppose the action that produced the induced current.

Objective 4

Characteristics of inductance

a. Inductance is the physical property of a circuit or device that indicates an ability to oppose a change in current.

b. Inductance may be defined as the ability to induce an EMF into a conductor when there is a change in current flow.

c. The symbol for inductance is the letter L.

d. The unit of measurement for inductance is the Henry.

- A Henry is the amount of inductance that induces an EMF of 1 volt into a conductor when the current changes at the rate of 1 ampere per second.
- The Henry is expressed symbolically with the letter H.

  Note: The Henry is a relatively large unit, therefore the millihenry (mH) and the microhenry (uH) are the units generally used in practice.

Information Sheet

Objective 5

Factors affecting inductors

a. An inductor is a physical device consisting of a coil of wire usually wound on a core.

Note: An inductor may also be called a *coil* or *choke*.

b. The inductance of a coil varies as the square of the number of turns.

c. Inductance of a coil may be increased dramatically by winding the coil on a core of material that has a high permeability.

d. Inductance varies inversely with the length of the coil.

Objective 6

Power characteristics in an inductive circuit

a. No power is dissipated in a pure inductance.

Note: Scientists are unable to make totally pure inductors; therefore, all inductors have some resistance within the wire of which they are made.

b. Power dissipation in an RL circuit occurs in the resistance within the circuit.

c. Since power is dissipated only in the resistance, it may be calculated using the standard power formulas.

Examples: $P = EI$ $P = I^2R$ $P = \frac{E^2}{R}$

Figure 5

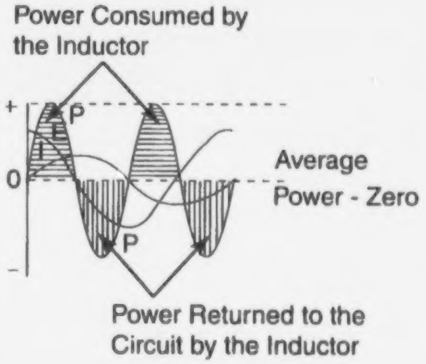
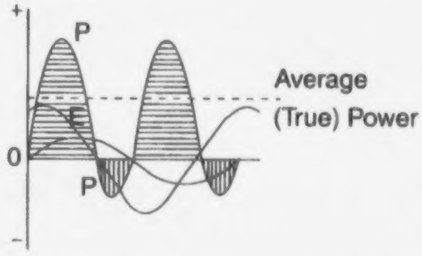


Figure 6



Objective 7

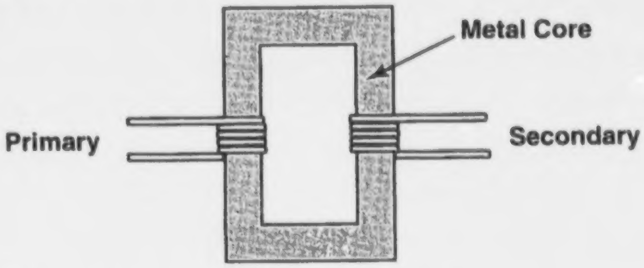
Characteristics of a transformer

a. The transformer is one use of the induction process.

b. Different electrical devices require different operating voltages. Transformers change these voltages to meet a specific need.

c. Transformers have three basic parts: a primary conductor, a secondary conductor, and a metal core.

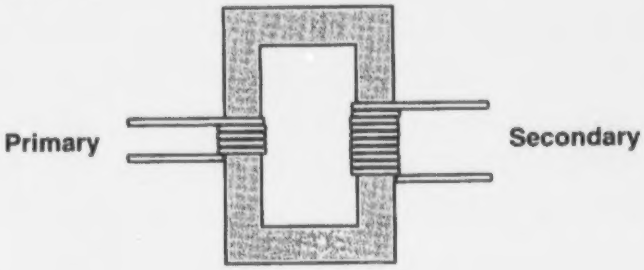
Figure 7



Reprinted with permission of NUS Training Corporation

d. When the windings on the primary side are decreased and the windings on the secondary side are increased, this is called a step-in transformer.

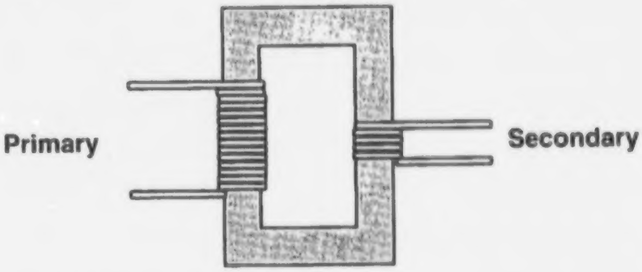
Figure 8



Reprinted with permission of NUS Training Corporation

e. When the windings on the primary side are increased and the windings on the secondary side decreased, this is called a step-down transformer.

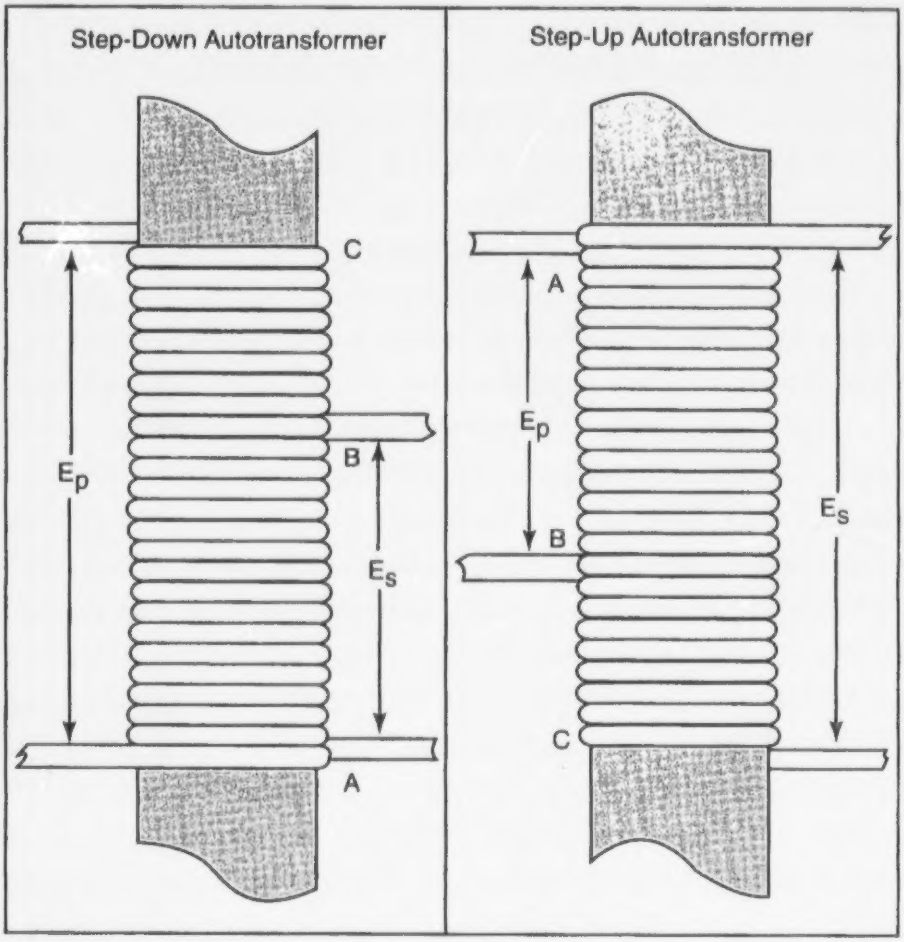
Figure 9



Reprinted with permission of NUS Training Corporation

f. Autotransformers have a single winding that acts as a primary and secondary.

Figure 10

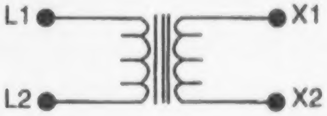

Step-Down Autotransformer
C
Ep
B
Es
A
Step-Up Autotransformer
A
Ep
B
Es
C

Objective 8

Classes of transformers

a. Single-phase

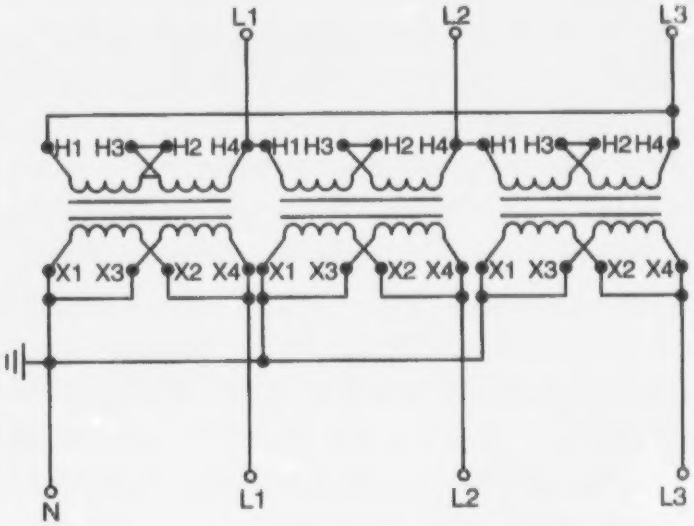
Figure 11



b. Three-phase

Note: Three single-phase transformers can be used to make a three-phase transformer if they are of the same values.

Figure 12


L1
L2
L3
H1
H3
H2
H4
H1
H3
H2
H4
H1
H3
H2
H4
X1
X3
X2
X4
X1
X3
X2
X4
X1
X3
X2
X4
N
L1
L2
L3

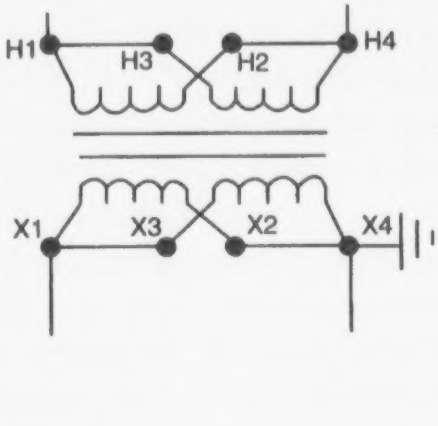
Objective 9

Transformer connections on a single-phase system

Note: These are the four most common connections used on dual winding, single-phase transformers.

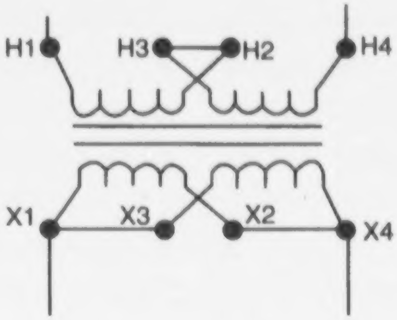
a. Parallel primary, parallel secondary (usually 240 volt to 120 volt)

Figure 13


H1
H3
H2
H4
X1
X3
X2
X4

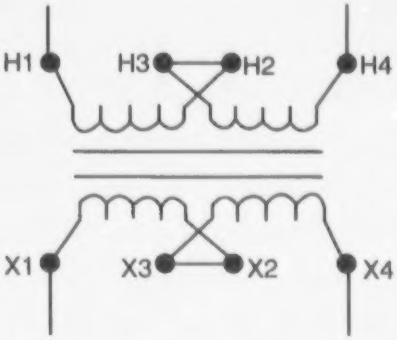
b. Series primary, parallel secondary (usually 80 volt to 120 volt)

Figure 14


H1
H3
H2
H4
X1
X3
X2
X4

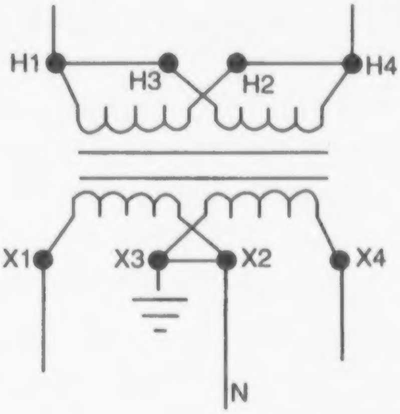
c. Series primary, series secondary (usually 480 volt to 240 volt)

Figure 15


H1
H3
H2
H4
X1
X3
X2
X4

d. Parallel primary, series secondary (usually 240 volt to 120 volt)

Figure 16


H1
H3
H2
H4
X1
X3
X2
X4
N

749

Objective 10

Other transformer connections found in electrical trades

a. Delta

Figure 17

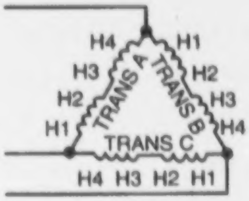
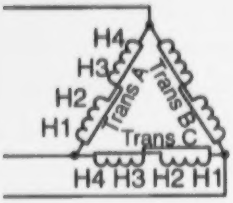

H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1

Figure 18


H4
H3
H2
H1
Trans A
Trans B
Trans C
H4 H3 H2 H1

b. Wye

Figure 19

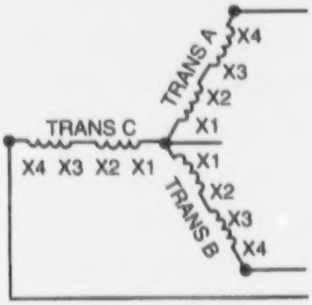
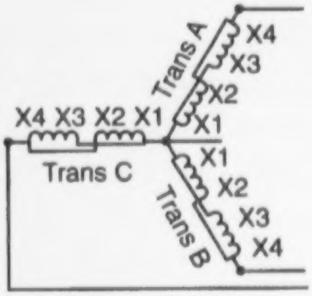

TRANS A
X4
X3
X2
X1
TRANS C
X4 X3 X2 X1
X1
X2
X3
X4
TRANS B

Figure 20


Trans A
X4
X3
X2
X1
X4 X3 X2 X1
Trans C
X1
X2
X3
X4
Trans B

c. Delta-wye

Figure 21

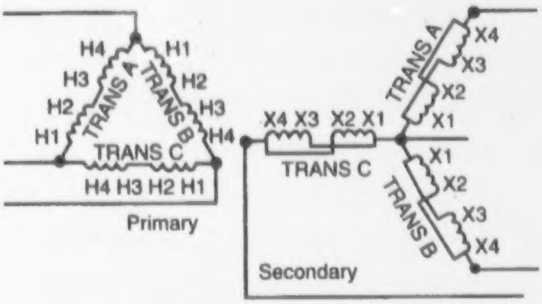

H4
H1
H3
H2
H2
H3
H1
H4
TRANS A
TRANS B
TRANS C
H4 H3 H2 H1
Primary
X4 X3 X2 X1
TRANS C
TRANS A
X4
X3
X2
X1
X1
X2
X3
X4
TRANS B
Secondary

Figure 22

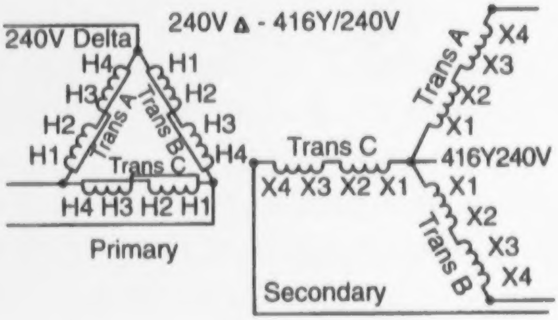
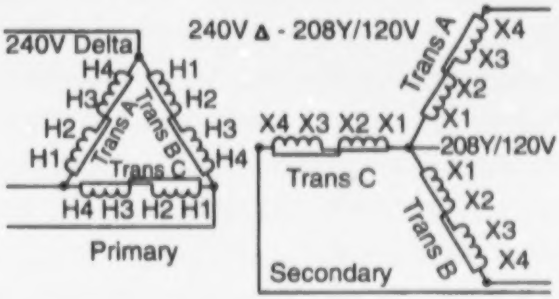

240V Delta
240V Δ - 416Y/240V
H4
H1
H3
H2
H2
H3
H1
H4
Trans A
Trans B
Trans C
H4 H3 H2 H1
Primary
Trans C
X4 X3 X2 X1
Trans A
X4
X3
X2
X1
416Y240V
X1
X2
X3
X4
Trans B
Secondary

Figure 23


240V Δ - 208Y/120V
240V Delta
H4
H3
H2
H1
H1
H2
H3
H4
Trans A
Trans B
Trans C
H4 H3 H2 H1
Primary
X4 X3 X2 X1
Trans C
208Y/120V
Trans A
X4
X3
X2
X1
X1
X2
X3
X4
Trans B
Secondary

d. Delta-delta

Figure 24

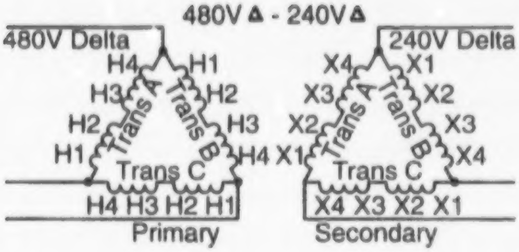

480V Δ - 240V Δ
480V Delta
H4
H3
H2
H1
H1
H2
H3
H4
Trans A
Trans B
Trans C
H4 H3 H2 H1
Primary
240V Delta
X4
X3
X2
X1
X1
X2
X3
X4
Trans A
Trans B
Trans C
X4 X3 X2 X1
Secondary

Figure 25

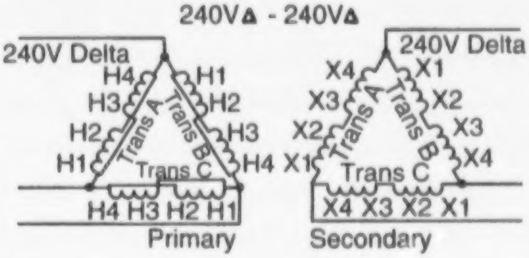

240VΔ - 240VΔ
240V Delta
H4
H3
H2
H1
H1
H2
H3
H4
Trans A
Trans B
Trans C
H4 H3 H2 H1
Primary
240V Delta
X4
X3
X2
X1
X1
X2
X3
X4
Trans A
Trans B
Trans C
X4 X3 X2 X1
Secondary

Figure 26

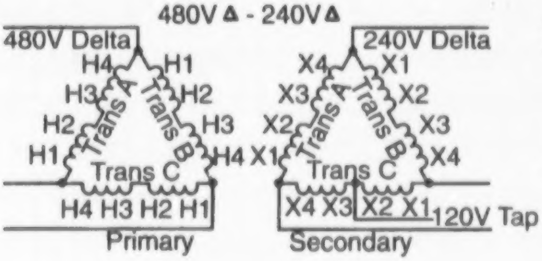
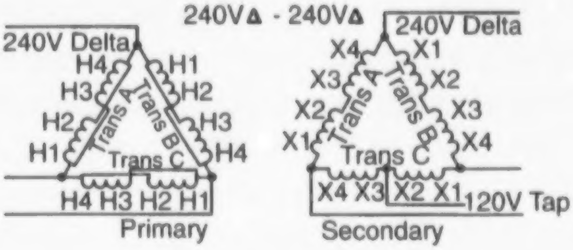

480V Δ - 240V Δ
480V Delta
H4
H3
H2
H1
H1
H2
H3
H4
Trans A
Trans B
Trans C
H4 H3 H2 H1
Primary
240V Delta
X4
X3
X2
X1
X1
X2
X3
X4
Trans A
Trans B
Trans C
X4 X3
X2 X1
120V Tap
Secondary

Figure 27


240VΔ - 240VΔ
240V Delta
H4
H3
H2
H1
H1
H2
H3
H4
Trans A
Trans B
Trans C
H4 H3 H2 H1
Primary
240V Delta
X4
X3
X2
X1
X1
X2
X3
X4
Trans A
Trans B
Trans C
X4 X3
X2 X1
120V Tap
Secondary

Objective 11

Power in three-phase circuits

a. **Delta**—Voltage across each load member is full-line voltage; amperage in each member is √3 x line amps or 1.732 x amps.

b. **Wye**—Ampereage in each member is full-line amperage; voltage across each member is √3 x line volts or 1.732 x volts.

Note: To find the power in delta or wye circuits, use the formula $P = I \times \sqrt{3} \times E$.

Example: A three-phase circuit has 10 amperes measured on each line. The voltage is 480 volts. It is not known whether the circuit is delta or wye. What is the power of the circuit?

Solution: $P = I \times \sqrt{3} \times E$

$= 10 \times 1.732 \times 480$

$= 8{,}314$ VA

$= 8.3$ kVA

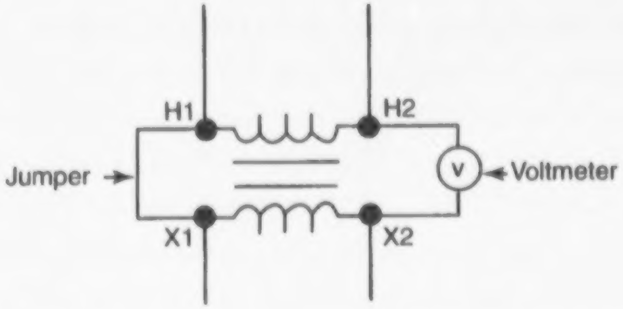
Objective 12

Testing for polarity

a. When testing a transformer for polarity, there are two kinds of windings: additives and subtractives.

b. When testing a transformer for polarity, connect the primary to the secondary on one side, and connect a meter between the primary and secondary on the other side. Apply the primary voltage. If the polarity is additive, the meter will read the primary voltage plus the secondary voltage. If the polarity is subtractive, the meter will read something less than the applied voltage.

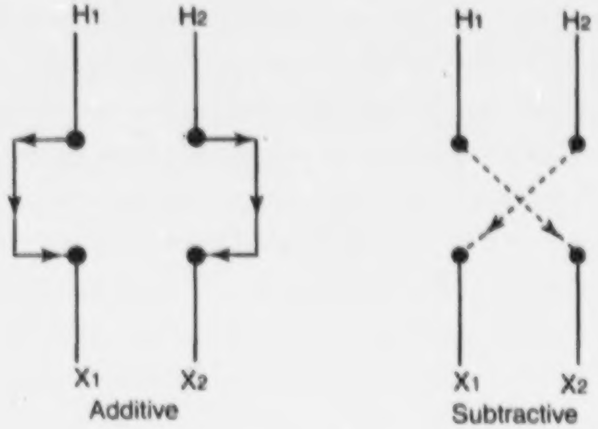
Figure 28



c. When finding the taps for an additive transformer, the taps are usually directly under each other.

d. When finding the taps for a subtractive transformer, the taps are usually opposite each other.

Figure 29

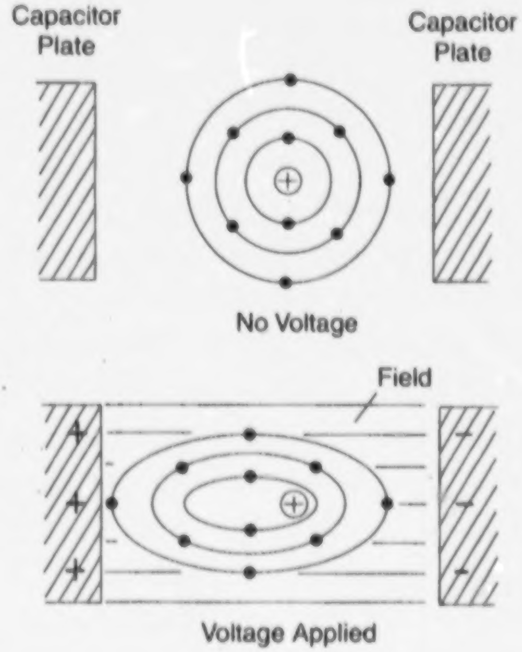

H1
H2
X1
X2
Additive
H1
H2
X1
X2
Subtractive

Objective 13

Characteristics of capacitance

a. The property of a circuit or device that enables it to store electrical energy with an electrostatic field is called capacitance.

Figure 30


Capacitor Plate
Capacitor Plate
No Voltage
Field
+
+
+
−
−
−
Voltage Applied

b. A device that is made to have specific value of capacitance is called a capacitor.

- The number of electrons that a capacitor can store for a given applied voltage is a measure of its capacitance.
- A capacitor has the ability to store electrons and discharge them at a later time.

c. A capacitor is a device constructed of two metal plates separated by a dielectric.

Figure 31

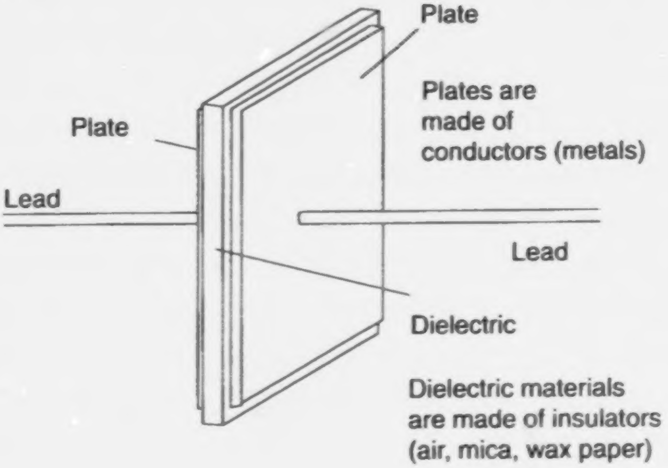
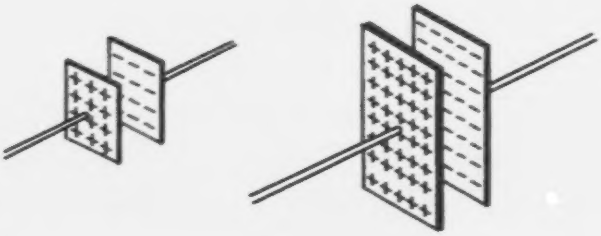


Plate
Plates are made of conductors (metals)
Plate
Lead
Lead
Dielectric
Dielectric materials are made of insulators (air, mica, wax paper)

d. Capacitance of a capacitor is determined by three factors:

- The **area** of the metal plates.

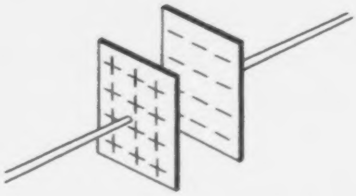
Figure 32



- The **spacing** between the plates.

  Note: The distance between two charges determines their effect. Increasing the distance between the plates decreases capacitance.

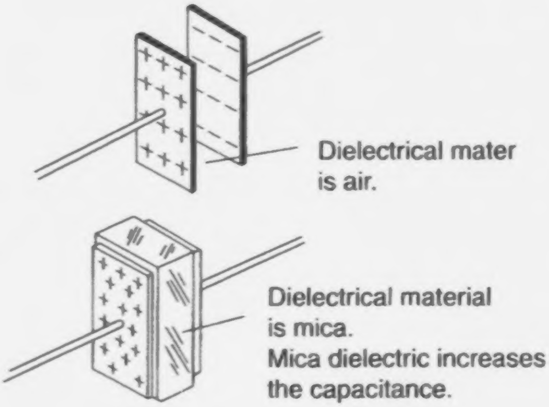
Figure 33



- The **type** or **nature** of the dielectric.

  Note: Changing the dielectric material changes the capacitance.

Figure 34


Dielectrical mater
is air.
Dielectrical material
is mica.
Mica dielectric increases
the capacitance.

e. The unit of capacitance is the farad (F).

f. One farad is the amount of capacitance that will store a charge of 1 coulomb when 1 volt of EMF is applied.

Note: The farad is a very large unit and therefore is commonly expressed in terms of microfarads or picofarads.

g. Capacitance may be expressed in terms of charge and voltage by the formula $C = Q/E$ (C is the capacitance, Q is the quantity of electrical charge in coulombs, and E is the applied voltage).

Objective 14

Types, ratings, and common defects of capacitors

a. Capacitors are classified according to a number of factors.

- There are two basic types: fixed-value capacitors and variable capacitors.
- Capacitors are classified by the type of dielectric used, such as mica, ceramic, paper, or mylar.
- Capacitors may be an electrolytic type.

  Note: Polarity must be observed.

b. Capacitors are rated according to value of capacitance.

c. Defect in capacitors are related to four common failures:

- Shorts occur when the dielectric is punctured or otherwise fails.
- A capacitor may open when one or both leads become disconnected from the plates.
- Excessive leakage may develop when a resistive path forms between the two plates (partial failure of dielectric).
- The capacitor may change in value due to a manufacturing defect or improper use (excessive temperature or applied voltage may cause a change in value).

Objective 15

Capacitive AC circuits

a. When voltage is applied to a capacitor in an AC circuit, it will appear that electrons are flowing through the circuit.

b. Electrons will not travel through the dielectric of a capacitor.

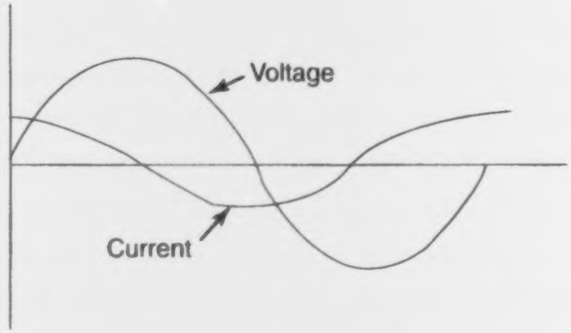
c. As the applied AC voltage increases and decreases in amplitude, the capacitor will charge and discharge.

d. The movement of electrons from one plate to the other represents current flow.

e. Current and voltage do not flow in phase in a capacitive circuit: when the current is at its maximum, the voltage is at 0, thus the relationship is 90 degrees out of phase.

f. The current leads the applied voltage in a capacitive circuit.

Figure 35



g. After a capacitor is initially charged by an AC voltage, the voltage stored on the plates opposes any change in the applied voltage.

Note: This opposition to a change in voltage is known as *capacitive reactance.*

h. Capacitive reactance is represented as X_c, and is measured in ohms (Ω).

i. The formula for capacitive reactance is: $X_c = {}^1/_2\pi fC$.

Where: $\pi = 3.14$
† = Frequency in Hertz
C - Capacitance in Farads

Example: What is the capacitive reactance of a 10-microfarad capacitor at 60 hertz?

Solution: $X_c = {}^1/_2\pi fC$

$= 1/(2)(3.14)(60)(0.000010)$

$= 1/0.003768$

$= 265.39\Omega$

j. A capacitor is effective in controlling current in an AC circuit.

k. The formula used to calculate current when the voltage and the capacitive reactance is known is: $I = E/X_c$.

Where: I = Current
E = Voltage
X_c - Capacitive Reactance

Example: A 20-microfarad capacitor has 240 volts applied at 60 hertz. What is the value of the current flow through the circuit?

Solution: $X_c = {}^1/_2\pi fC$

$= 1/(2)(3.14)(60)(0.000020)$

$= 1/0.007536$

$= 132.7\Omega$

Using X_c, it is now possible to calculate the current.

$I = E/X_c$

$= 240/132.7$

$= 1.81A$

l. Capacitors are commonly used for power factor correction.

Objective 16

Inductive AC circuits

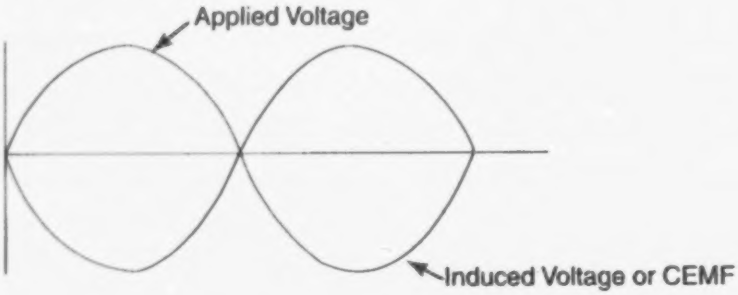
a. In AC circuits, inductors offer opposition to current flow.

b. As an AC voltage is applied to an indoor or an inductive circuit, a magnetic field expands and collapses around the inductor.

c. This magnetic field induces a voltage in the windings of the inductor. This is called counter-electromotive force or CEMF. The CEMF is always less than the applied EMF.

d. CEMF is an effective means of controlling current flow because it is 180 degrees out of phase of the applied voltage and opposes the applied voltage.

Figure 36



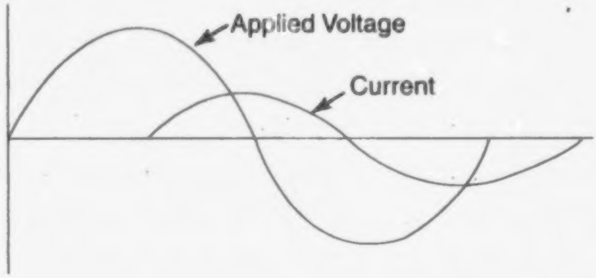
e. Opposition to current flow is known as *inductive reactance*.

f. Inductive reactance is a factor of the size of the inductor and the frequency of the applied voltage.

g. Inductive reactance is represented as X_L and is expressed in ohms (Ω).

h. Inductive reactance will lag the applied voltage in an AC circuit.

Figure 37



i. The formula for inductive reactance is: $X_L = 2\pi fL$.

Where:
$\pi = 3.14$
f = Frequency in Hertz
L - Inductance in Henries

Example: What is the inductive reactance of a 0.75-henry coil at 60 hertz?

Solution:

$$X_L = 2\pi fL$$

$$= (2)(3.14)(60)(0.75)$$

$$= 282.6\Omega$$

j. Current in an inductive reactive circuit can be calculated using the following formula: $I = E/X_L$.

Where:
I = Current
E = Voltage
X_L - Inductive Reactance

Example: How much current flows through a 0.25-henry inductor when 120 volts at 60 hertz is applied?

Solution:

$$X_L = 2\pi fL$$

$$= (2)(3.14)(60)(0.25)$$

$$= 94.20\Omega$$

Using X_L the current may now be calculated.

$$I = E/X_L$$

$$= 120/94.20$$

$$= 1.27A$$

k. The combination of both resistance and inductive reactance is called *impedance.*

l. Due to the phase shift, resistance and inductive reactance cannot be added directly.

m. Impedance is the vector sum of the inductive reactance and the resistance in the circuit.

n. Impedance is represented as Z and is expressed in ohms (Ω).

o. Impedance is defined by Ohm's Law as $I = E/Z$.

Where:
I = Current
E = Voltage
Z = Impedance

p. The most common inductive circuit consists of an inductor connected in series with a resistor. This is called an *RL circuit.*

q. The RL circuit may be expressed mathematically as: $Z = \sqrt{R^2 + X_L{}^2}$.

Example: What is the impedance of a 0.1-henry inductor in series with a 4,700-ohm resistor, with 240 volts at 60 hertz applied?

Solution: $X_L = 2\pi fL$

$$= (2)(3.14)(60)(0.1)$$

$$= 37.68\Omega$$

Using X_L, it is now possible to calculate impedance.

$$Z = \sqrt{R^2 + X_L{}^2}.$$

$$= \sqrt{(4700)^2 + (37.68)^2}$$

$$= \sqrt{22090000 + 1419.78}$$

$$= \sqrt{22091419.78}$$

$$= 4700.15\Omega$$

Objective 17

Characteristic of power in an AC circuit

a. In an AC circuit, voltage and current are seldom in phase.

Note: The exception would be incandescent lights and resistance heating circuits.

b. The power or product of voltage and current must be multiplied by a power factor to determine the true power.

Example: Power (Watts) = Volts x Amperes or $P = E \times I$

$$\text{(Power factor) PF} = \frac{\text{True Power}}{\text{Apparent Power}}$$

c. By using a meter, one can determine the true power in a circuit.

Example: A voltmeter reads 120 volts and the ammeter reads 10 amps. A wattmeter gives a reading of 1,000 watts of true power.

Solution: $P = E \times I$

$$= 120 \times 10 = 1200 \text{ Watts of Apparent Power}$$

$$PF = \frac{1000}{1200} \text{ True Power}$$

$$= 83\% \text{ or } .83$$

Note: For three-phase circuits, the product of the voltage and amperage must be multiplied by 3.

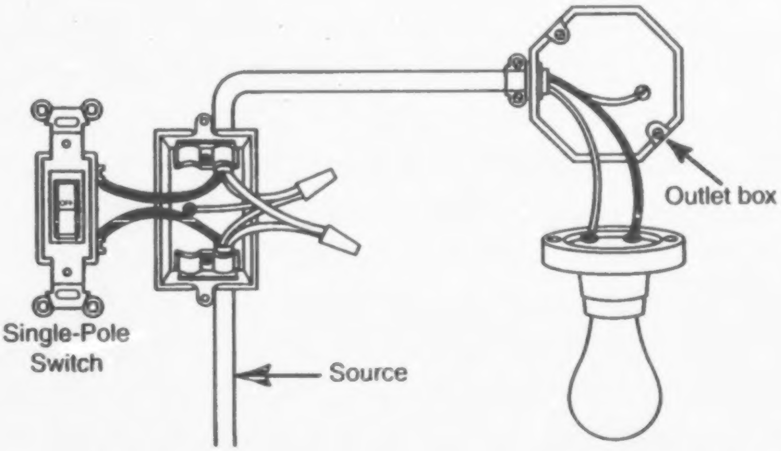
Objective 18

Basic switching circuits used in electricity

a. Single-pole switch

Note: A single-pole switch breaks the circuit only in one position.

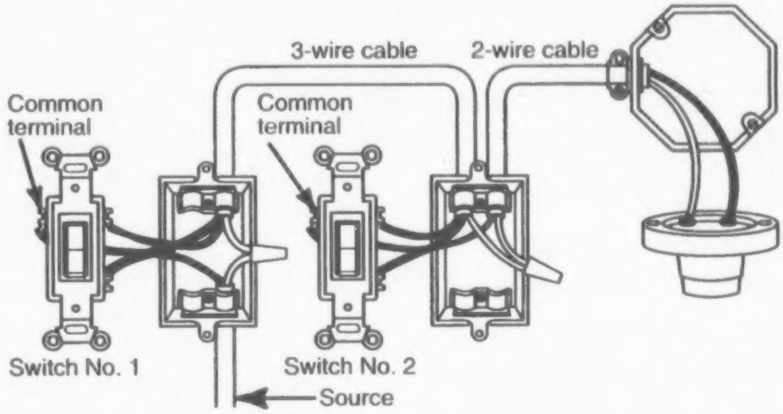
Figure 38



b. Three-way switch

Note: A three-way switch breaks the circuit in two positions.

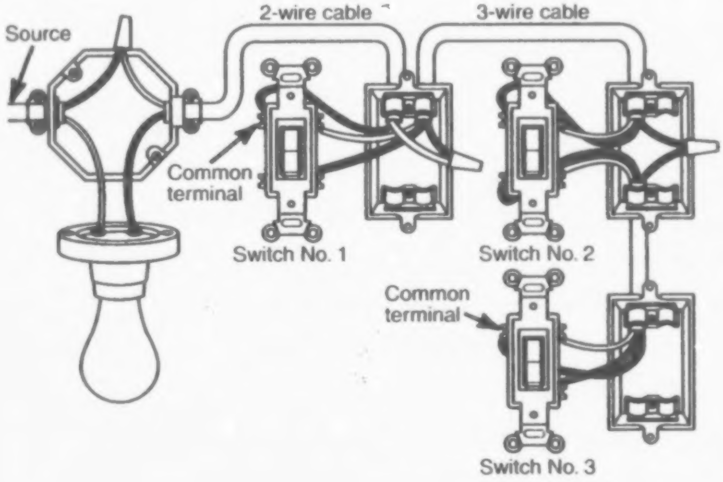
Figure 39


3-wire cable
2-wire cable
Common terminal
Common terminal
Switch No. 1
Switch No. 2
Source

c. Four-way switch

Note: When wired with two three-way switches, as many four-way switches can be installed as needed, making the operation from many positions.

Figure 40


Source
2-wire cable
3-wire cable
Common terminal
Switch No. 1
Switch No. 2
Common terminal
Switch No. 3

Unit Contents

Student Components

Student Page

Learning Activities Sheet 12–3

Objective Sheet 12–5

Information Sheet 12–7

* Focus Assignment

Identify Environments and Structures Requiring Electrical Wiring Installations 77

* Assignment Sheet

1—Reference The *National Electrical Code* to Identify Uses of Wiring Methods 79

* Job Sheets

1—Install a Set-Screw Conduit Fitting 85
2—Install a Compression-Type Conduit Fitting 87
3—Prepare MC Cable for Termination 91
4—Install a Connector onto Liquidtight Flexible Metal Conduit 99
5—Install a Connector onto Rigid Nonmetallic Conduit 103

* Focus Assignment, Assignment Sheet and Job Sheets are located in Student Workbook 2

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "Identify Environments and Structures Requiring Electrical Wiring Installations."

☐ 4. **Study** Information Sheet, Objectives 1 and 2.

☐ 5. **Research** Online resources concerning different types of cable at www.afcweb.com

☐ 6. **Study** Information Sheet, Objective 3.

☐ 7. **Do** Assignment Sheet 1, "Reference the *National Electrical Code* to Identify Uses of Wiring Methods."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, repeat Steps 6 and 7.

☐ 9. **Do** Job Sheet 1, "Install a Set-Screw Conduit Fitting."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 9.

☐ 11. **Do** Job Sheet 2, "Install a Compression-Type Conduit Fitting."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 11.

Learning Activities Sheet

☐ 13.	**Do**	Job Sheet 3, "Prepare MC Cable for Termination."
☐ 14.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 13.
☐ 15.	**Do**	Job Sheet 4, "Install a Connector Onto Liquidtight Flexible Metallic Conduit."
☐ 16.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 15.
☐ 17.	**Do**	Job Sheet 5, "Install a Connector Onto Rigid Nonmetallic Conduit."
☐ 18.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat Step 17.
☐ 19.	**Check**	With instructor for any additional assignments to be completed.
☐ 20.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
☐ 21.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify wiring methods and their common applications. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to wiring methods with their definitions.
2. Identify wiring methods found in electrical trades.
3. Match wiring methods with their common applications.
4. Identify environments and structures requiring electrical wiring installations. (Focus Assignment)
5. Reference the *National Electrical Code* to identify uses of wiring methods. (Assignment Sheet 1)
6. Install a set-screw conduit fitting (Job Sheet 1)
7. Install a compression-type conduit fitting. (Job Sheet 2)
8. Prepare MC cable for termination. (Job Sheet 3)
9. Install a connector onto liquidtight flexible metallic conduit. (Job Sheet
10. Install a connector onto rigid nonmetallic conduit. (Job Sheet 5)

Information Sheet

Objective 1

Terms and definitions

a. **Cable**—A factory assembly of two or more conductors having an overall covering.

b. **Cable Sheath**—A covering over the conductor assembly that may include one or more metallic members, strength members, or jackets.

c. **Exposed (as applied to wiring methods**—On or attached to the surface or behind panels designed to allow access.

d. **Premises Wiring (System)**—That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of their associated hardware, fittings, and wiring devices, both permanently and temporarily installed, that extends from the service point of utility conductors or source of power such as a battery, a solar photovoltaic system, or a generator, transformer, or converter windings, to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

e. **Raceway**—An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in the *NEC*. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

f. **Nonmetallic-Sheathed Cable (Romex)**—A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material.

g. **Concealed Knob-and-Tube Wiring**—A wiring method using knobs, tubes, and flexible nonmetallic tubing for the protection and support of single insulated conductors.

h. **Rigid Metal Conduit**—A listed metal raceway of circular cross section with integral or associated couplings, approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity.

i. **Electrical Metallic Tubing (EMT)**—A listed metallic tubing of circular cross section approved for the installation of electrical conductors when joined together with listed fittings.

j. **Flexible Metal Conduit (Greenfield)**—A raceway of circular cross section made of helically wound, formed, interlocked metal strip.

k. **Liquidtight Flexible Metal Conduit (Sealtite)**—A listed raceway of circular cross section having an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core with associated couplings, connectors, and fittings and approved for the installation of electric conductors.

l. **Electrical Nonmetallic Tubing (ENT)**—A pliable corrugated raceway of circular cross section with integral or associated couplings, connectors, and fittings listed for the installation of electric conductors. It is composed of a material that is resistant to moisture and chemical atmospheres and is flame retardant, (A pliable raceway is a raceway that can be bent by hand with a reasonable force, but without other assistance.)

m. **Type MC Cable**—A factory assembly of one or more insulated circuit conductors with or without optical fiber members enclosed in an armor of interlocking metal tape, or a smooth or corrugated metallic sheath.

n. **Rigid Nonmetallic Conduit (PVC)**—A type of conduit and fittings of nonmetallic material that is resistant to moisture and chemical atmospheres and is suitable for underground use.

o. **Equipment**—A general term including material, fittings, devices, appliances, fixtures, and apparatus, used as a part of, or in connection with, and electrical installation.

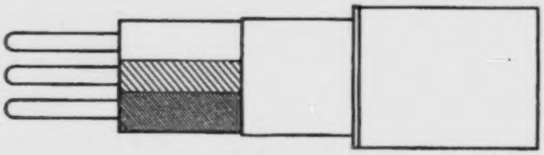
p. **Fitting**—An accessory, such as a locknut, bushing, or other part of a wiring system, that is intended primarily to perform a mechanical rather than an electrical function.

Objective 2

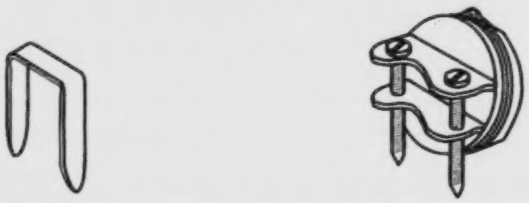
Wiring methods found in electrical trades

a. Nonmetallic sheathed cable (Romex)

Figure 1



NM cable

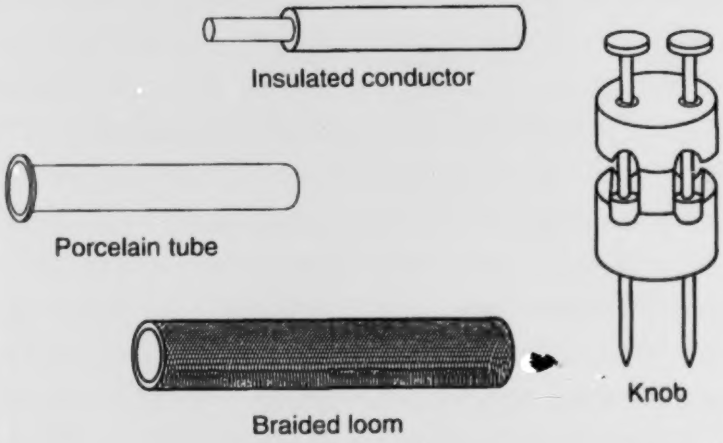


Staple

Connector

b. Concealed knob-and-tube wiring

Figure 2



Insulated conductor

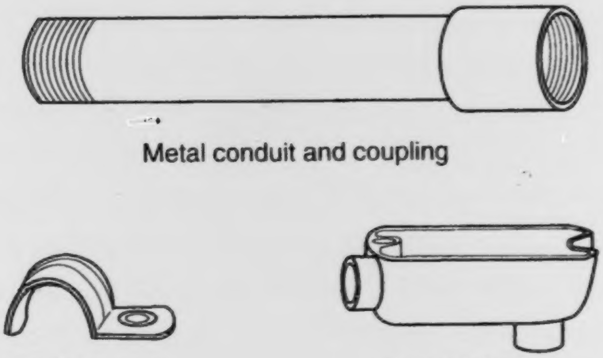
Porcelain tube

Braided loom

Knob

c. Rigid metal conduit

Figure 3



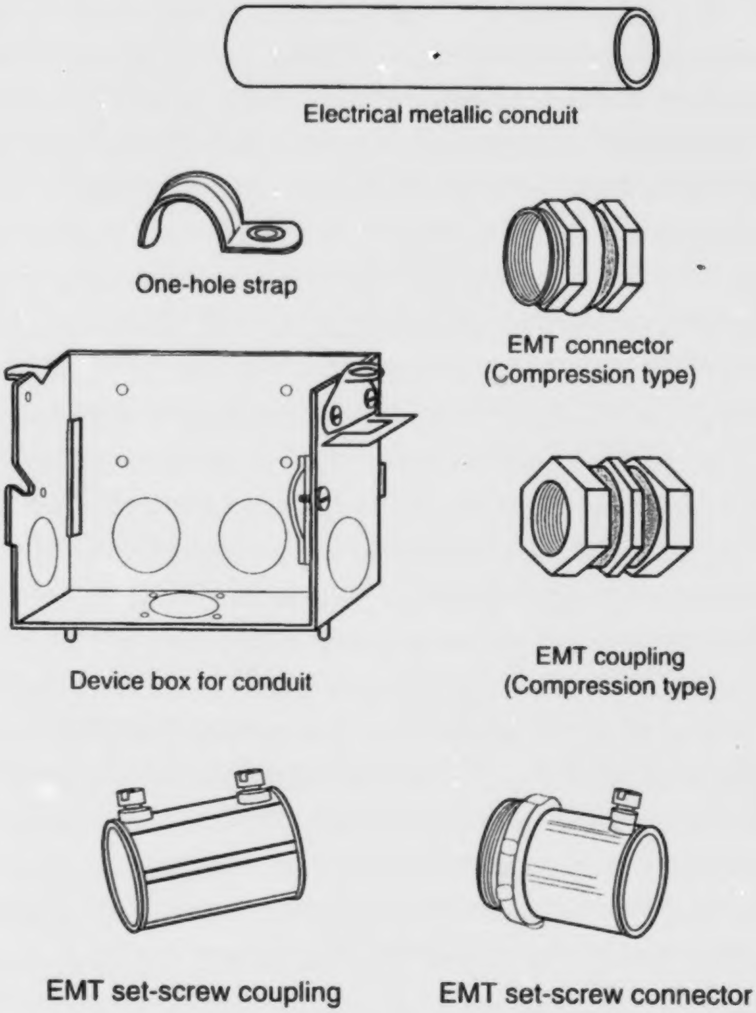
Metal conduit and coupling

One-hole strap

Conduit body

d. Electrical metallic tubing (EMT)

Figure 4



Electrical metallic conduit

One-hole strap

EMT connector
(Compression type)

Device box for conduit

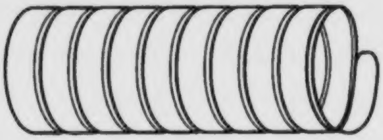
EMT coupling
(Compression type)

EMT set-screw coupling

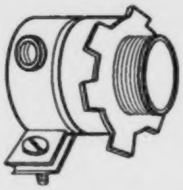
EMT set-screw connector

e. Flexible metal conduit

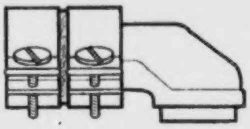
Figure 5



Flexible metal conduit



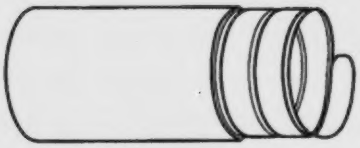
Straight connector



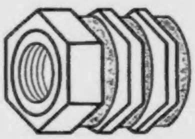
90° connector

f. Liquidtight flexible metal conduit

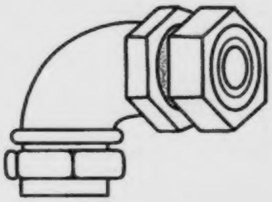
Figure 6



Liquid tight flexible metal conduit



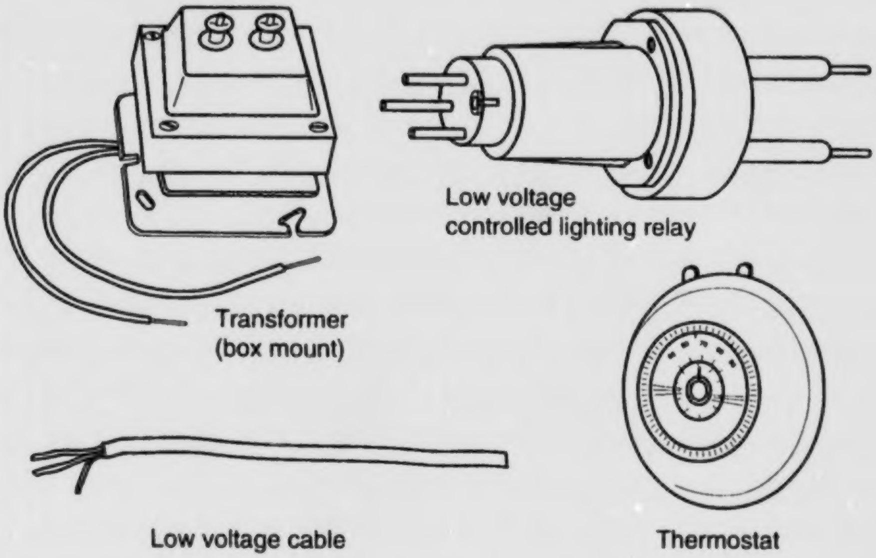
Straight liquid tight connector



90° liquid tight connector

g. Low voltage devices

Figure 7



Transformer (box mount)

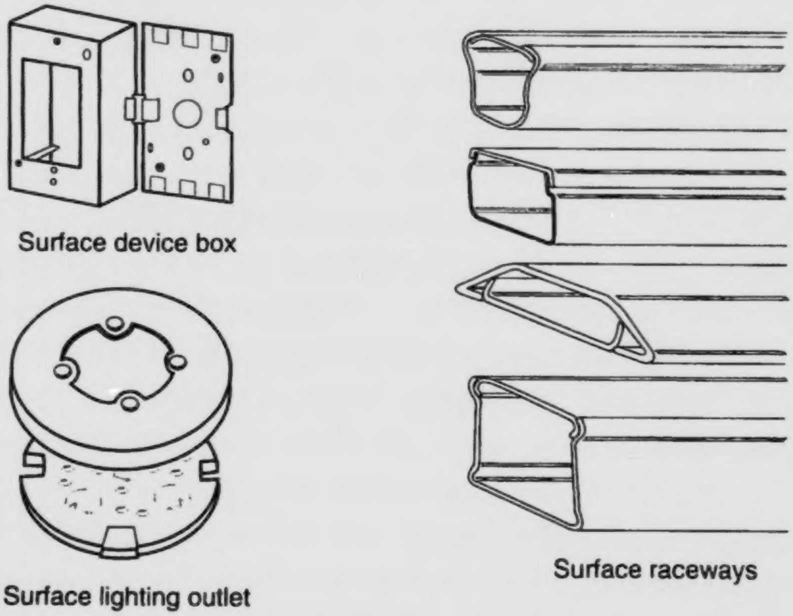
Low voltage controlled lighting relay

Low voltage cable

Thermostat

h. Surface raceways and boxes

Figure 8



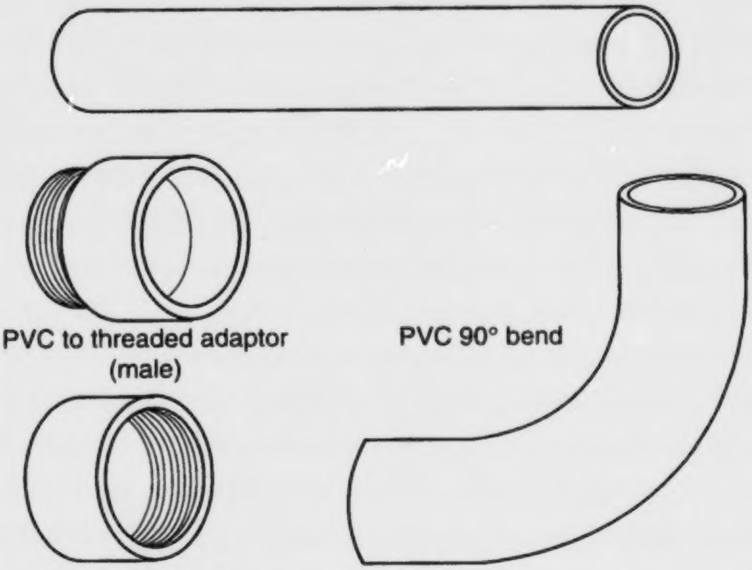
Surface device box

Surface lighting outlet

Surface raceways

i. Rigid nonmetallic conduit (PVC) fittings and connections

Figure 9



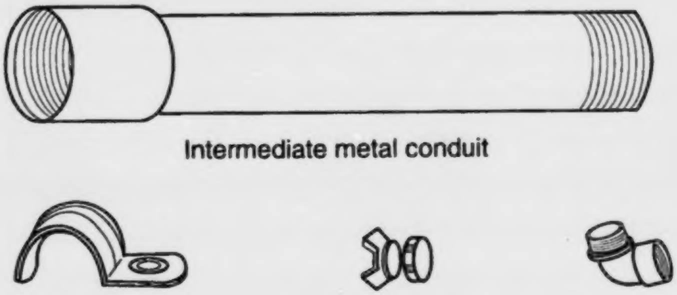
PVC to threaded adaptor (male)

PVC 90° bend

PVC to threaded adaptor (female)

j. Intermediate metal conduit

Figure 10



Intermediate metal conduit

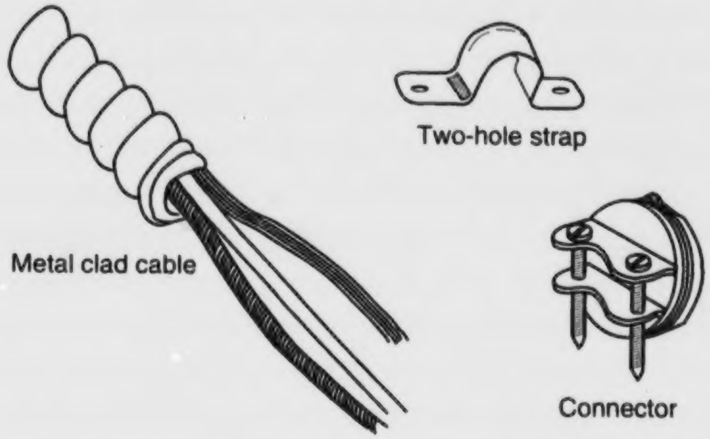
One-hole strap

Capped ell

Threaded ell

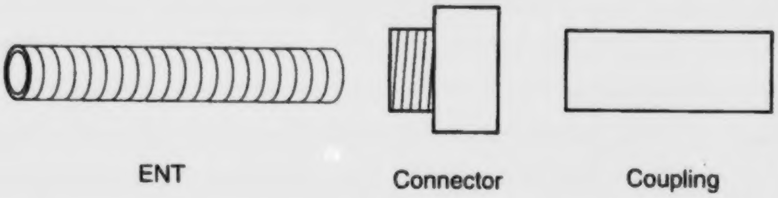
k. Metal clad cable

Figure 11


Two-hole strap
Metal clad cable
Connector

l. Electrical nonmetallic tubing (ENT)

Figure 12


ENT
Connector
Coupling

Objective 3

Wiring methods and their common applications

a. Cable

- Nonmetallic-sheathed cable (*NEC* Art: 334)
  - General residential rough-in
  - Circuit extensions in existing dwellings

    Note: Nearly all the premises wiring in most new residential homes is done with Type NM and NMC cable.
- Underground feeder and branch circuit cable (UF)—Direct burial for yard lights or extensions

b. Concealed knob-and-tube wiring (*NEC* Art: 394)

- Extensions of existing installations
- Elsewhere by special permission

c. Rigid metal conduit (*NEC* Art: 344)

- Through-eave service masts
- Underground circuit extension
- In concrete wall, floors, or ceilings

  Note: Wiring in poured basement walls, ceilings, and floors is usually done with rigid metal conduit.

- Underground service riser
- Commercial and industrial locations
- Hazardous locations

d. Electrical metallic tubing (*NEC* Art: 358)

- Service raceway

  Note: EMT is not suitable for through-eave installations.

- Protecting grounding electrode conductor
- Commercial and industrial locations

e. Flexible metal conduit (*NEC* Art: 348)

- Connecting recessed lighting fixtures
- Enclosing motor leads

f. Liquidtight flexible metal conduit (*NEC* Art: 350)

- Connecting air conditioning condensers to disconnects
- Enclosing motor leads needing protection form liquids and vapors

g. Low voltage (*NEC* Art: 720)

- Chime circuits
- Intercom wiring
- Thermostat circuits
- Lighting control

h. Surface raceways (*NEC* Art: 386)

- Interior circuit extensions where concealed work is not necessary or not possible
- On interior concrete surfaces

i. Rigid nonmetallic conduit (PVC) (*NEC* Art: 352)

- Underground circuits
- Wet locations
- Where subject to corrosion or chemicals
- Schedule 80 in areas exposed to physical damage

j. Intermediate metal conduit (*NEC* Art: 342)

- Lighter weight and a thinner wall than rigid
- May be used in all atmospheric conditions
- Hazardous locations
- Underground circuits

k. Metal-clad cable (*NEC* Art: 330)

- Services
- Feeders
- Branch circuits
- Power, lighting, and signal circuits

l. Electrical nonmetallic tubing (*NEC* Art: 362)

- Locations subject to severe corrosive influences
- Suspended ceilings
- Concealed within walls, floors, and ceilings

Unit Contents

Student Components

Student Page

Learning Activities Sheet 13–3
Objective Sheet 13–7
Information Sheet 13–9

* Focus Assignment

Report on a Fire 107

* Assignment Sheets

1—List Conductors in Order, By Size 109
2—Calculate Ampacity of Conductors, Given Insulation and Conductor Type 111
3—Calculate Corrected Ampacity of Conductors 113
4—Select Conductors for Various Ampacities and Temperatures 115
5—Calculate Ampacity of Conductors, Given Number of Conductors in Raceway 117
6—Calculate Ampacity and Conductor Sizes for Specific Types of Loads 119
7—Select Cords for Various Applications 121
8—Select Proper Types of Insulation 123

* Job Sheets

1—Install Cord on Utilization Equipment 125
2—Use a Fish Tape to Install Wire in Conduit 127
3—Prepare an Aluminum Conductor for Termination 129
4—Splice Solid Conductors Using a Wire Nut 131

* Focus Assignment, Assignment Sheets and Job Sheets are located in Student Workbook 2.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "Report On a Fire."

☐ 4. **Study** Information Sheet, Objectives 1 through 10.

☐ 5. **Do** Assignment Sheet 1, "List Conductors In Order, By Size."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat Steps 4 and 5.

☐ 7. **Do** Assignment Sheet 2, "Calculate Ampacity of Conductors, Given Insulation and Conductor Type."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, repeat Steps 4 and 7.

☐ 9. **Do** Assignment Sheet 3, "Calculate Corrected Ampacity of Conductors."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 4 and 9.

☐ 11. **Do** Assignment Sheet 4, "Select Conductors for Various Ampacities and Temperatures."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat Steps 4 and 11.

☐ 13. **Do** Assignment Sheet 5, "Calculate Ampacity of Conductors, Given Number of Conductors in Raceway."

☐ 14. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, repeat Steps 4 and 13.

☐ 15. **Do** Assignment Sheet 6, "Calculate Ampacity and Conductors Sizes for Specific Types of Loads."

☐ 16. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat Steps 4 and 15.

☐ 17. **Study** Information Sheet, Objective 11.

☐ 18. **Do** Assignment Sheet 7, "Select Cords for Various Applications."

☐ 19. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, repeat Steps 17 and 18.

☐ 20. **Do** Assignment Sheet 8, "Select Proper Types of Insulation."

☐ 21. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 22. If the evaluation is not satisfactory, repeat Steps 17 and 20.

☐ 22. **Do** Job Sheet 1, "Install Cord on Utilization Equipment."

☐ 23. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 24. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 22.

☐ 24. **Do** Job Sheet 2, "Use a Fish Tape to Install Wire in Conduit."

☐ 25. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 26. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 24.

☐ 26. **Do** Job Sheet 3, "Prepare an Aluminum Conductor for Termination."

☐ 27. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 28. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 26.

☐ 28. **Do** Job Sheet 4, "Splice Solid Conductors Using a Wire Nut."

☐ 29. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 30. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 28.

☐ 30. **Check** With instructor for any additional assignments to be completed.

☐ 31. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 32. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to select and install proper conductors. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to conductors with their definitions.
2. List factors that determine conductor type and size.
3. Select from a list, characteristics of good connections.
4. Identify types of connectors, terminals, and lugs.
5. Match letter designations for wire insulation with their correct characteristics.
6. Identify types of insulation, given its characteristics, applications, and code letters.
7. List three conductors commonly found in electrical wiring.
8. Complete statements about color codes for conductors.
9. Complete statements about the means of identifying "grounded" and equipment "grounding" conductors.
10. Match with their uses, types of cables found in the electrical field.
11. Select true statements about cords and their conductors.
12. Report on an electrical fire. (Focus Assignment)
13. List conductors in order, by size. (Assignment Sheet 1)
14. Calculate ampacity of conductors, given insulation and conductor type. (Assignment' Sheet 2)
15. Calculate corrected ampacity of conductors. (Assignment Sheet 3)
16. Select conductors for various ampacities and temperatures. (Assignment Sheet 4)
17. Calculate ampacity of conductors, given number of conductors in raceway. (Assignment Sheet 5)

18. Calculate ampacity and conductor sizes for specific types of loads. (Assignment Sheet 6)

19. Select cords for various applications. (Assignment' Sheet 7)

20. Select proper types of insulation. (Assignment Sheet 8)

21. Install cord on utilization equipment. (Job Sheet 1)

22. Use a fish tape to install wire in conduit. (Job Sheet 2)

23. Prepare an aluminum conductor for termination. (Job Sheet 3)

24. Splice solid conductors using a wire nut. (Job Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Aluminum wire**—Conductor made of aluminum

b. **Ampacity**—The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

c. **American wire gauge (AWG)**—A series of specified diameters and thicknesses established as a standard in the United States; also known as Brown and Sharp gauge (B and S gauge)

d. **Bare conductor**—A conductor having no covering or electrical insulation

e. **Cable**—A factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant nonmetallic material

f. **Circular mils**—The diameter of a conductor in thousandths of inches multiplied times itself

g. **Color coding**—Assigning colors to conductors based on their uses

h. **Copper-clad aluminum**—Aluminum conductors with an outer coating of copper metallurgically bonded to the aluminum core

i. **Copper wire**—Conductor made of copper

j. **Cord**—Two-(or more) stranded conductors grouped together in a flexible covering

k. **Covered**—Conductor encased within material of composition or thickness not recognized by the *NEC* as electrical insulation

l. **Fish tape**—Long tape of steel, nylon, or other material used to push or pull a conductor into a raceway

m. **Grounded conductor**—A system or circuit conductor that is intentially grounded (connected to the earth or some conductor that serves in place of the earth)

n. **Grounding conductor**—Conductors used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes

o. **Insulated**—Conductor encased within material of composition and thickness recognized by the *NEC* as electrical insulation

p. **KCMil**—One thousand circular kcmils

q. **Type letter**—Identification accepted by the trade in referring to the particular types of insulation

Information Sheet

Objective 2

Factors that determine conductor type and size

Note: *NEC* Table 310.16 covers sizing for most general wiring for 60°C (140°F) to 90°C (194°F) temperature ranges.

a. Full load amperes

b. Number of conductors

Note: See *NEC* table 310.15(B)(2)(a)

c. Type of load served

Note: *NEC* 424.3(B)—Fixed electric space-heating requires conductors for not less than 125 percent of full load.

NEC 430.22—Single motors require conductors for 125 percent of full-load current rating.

NEC 430.24—Conductors supplying several motors or a motor(s) and other load(s) shall have an ampacity at least equal to the sum of the full-load current rating of all motors, plus 25 percent of the highest rated motor, plus the ampere rating of other loads.

d. Length or run

Note: See *NEC* Articles 210.19 FPN #4 and 215.2(A)(4) FPN #2

e. Ambient temperature

Note: See *NEC* Tables 310.16 - 310.19.

Examples: Rooftop temperatures in summer approach the water boiling point of (100°C) 212°F.

Boiler and furnace rooms may reach temperatures near 100°C (212°F)

f. Voltage

Note: Most conductors for general use are rated for 600 volts. Higher voltage ratings are generally specified on a special order.

Objective 3

Characteristics of good connections

a. Are clean

b. Are tight

c. Are strong

d. Provide full contact

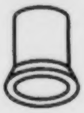
e. Use approved devices and oxidation inhibitors when connecting copper to aluminum

Objective 4

Types of connectors, terminals, and lugs

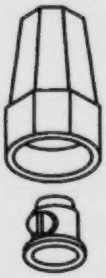
a. Crimp sleeve connector

Figure 1



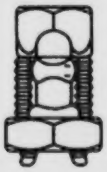
b. Set-screw lug

Figure 2



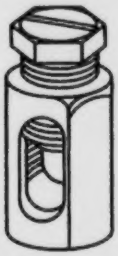
c. Split-bolt lug

Figure 3



d. Service-entrance lug

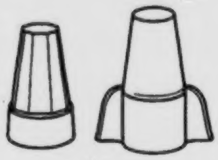
Figure 4



e. Wire-nut lugs

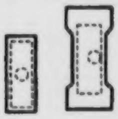
Note: These lugs are available in many configurations and sizes

Figure 5



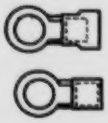
f. Crimp-type butt connectors

Figure 6



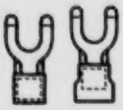
g. Ring lugs

Figure 7



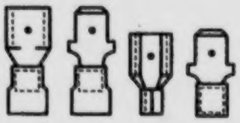
h. Spade connectors

Figure 8



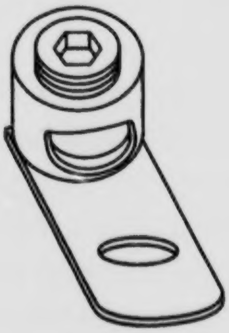
i. Quick disconnect connectors

Figure 9



j. Single terminal

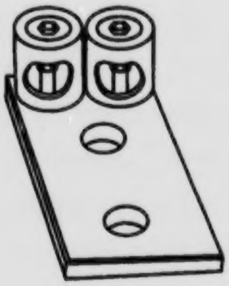
Figure 10



k. Twin or double terminal

Note: Twin terminals are available in many configurations

Figure 11

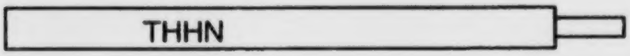


Objective 5

Letter designations for wire insulation

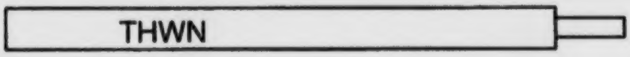
a. T - Thermoplastic Insulation
b. No H - 60 degree C insulation rating
c. H - 75 degree C insulation rating
d. HH - 90 degree C insulation rating
e. N - Nylon outer cover
f. W - Wet or damp
g. -2 - Suitable for 90 degree C in wet locations

Example 1



- T - Thermoplastic Insulation
- HH - 90 degree C insulation rating
- N - Nylon outer cover

Example 2



- T - Thermoplastic Insulation
- H - 75 degree C insulation rating
- W - Wet or damp
- N - Nylon outer cover

Information Sheet

Objective 6 | **Letter designations for wire insulation**

Insulation Type	*Code* Letters	Application	Characterisitcs
Moisture-resistant thermoplastic	TW	Dry and wet locations	Flame retardant; moisture resistant; no outer covering
Heat-resistant thermoplastic	THHN	Dry and damp locations	Flame retardant; heat resistant; nylon jacket
Moisture-and heat-resistant thermoplastic	THHW	Wet and dry locations	Flame retardant; moisture- and heat-resistant; no outer covering
Moisture-, heat-, and oil-resistant thermoplastic	MTW	Machine tool wiring in wet locations as permitted in NFPA Standard No. 79 (See Article 670.) Machine tool wiring in dry location as permitted in NFPA Standard No. 79 (See Article 670.)	Flame retardant; mositure, heat, and oil resistant; wet applications, no outer coverning; dry applications, nylon jacket
Moisture-, and heat-resistant thermoplastic	THW	Dry and wet locations Special applications within electric discharge lighting equipment; limited to 1,000 open-circuit volts or less (size 14-8 only as permitted in Section 410.31)	Flame retardant; moisture and heat resistant; no outer covering
Moisture-and heat-resistant thermoplastic	THWN	Dry and wet locations	Flame retardant; moisutre and heat resistant; nylon jacket

Objective 7 | **Conductors commonly found in electrical wiring**

a. Copper

b. Aluminum

c. Copper-clad aluminum

788

Objective 8

Color Codes for conductors commonly used by electricians

a. 120/240V, 1-phase: Black, red, white

b. 120/240V, 3-phase (with the high leg conductor): Black, orange, blue, white

c. 208Y/120V: Black, red, blue, white

d. 480Y/277V: Brown, orange, yellow, gray

e. Grounded Conductor: White or gray

f. Equipment Grounding Conductor; Bare or green

Objective 9

Grounded and grounding conductor identification

a. Means of identifying grounded conductors (*NEC* 200.6)

(1) Sizes No. 6 or smaller

An insulated grounded conductor of #6 or smaller shall be identified by a continuous white or natural gray outer finish or by three continuous white stripes on other than green insulation along its entire length.

(2) Sizes larger than No. 6

An insulated grounded conductor larger than #6 shall be identified either by a continuous white or natural gray outer finish or by three continuous white stripes on other than green insulation along its entire length or at the time of installation by a distinctive white marking at its terminations. This marking shall encircle the conductor or insulation.

b. Identification of equipment grounding conductors (*NEC* 250.119)

(1) Unless required elsewhere in the *Code*, equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section.

(2) Conductors larger than No. 6

An insulated or covered conductor larger than #6 copper or aluminum shall be permitted, at the time of installation, to be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is accessible. Identification shall be accomplished by one of the following:

- Stripping the insulation or covering from the entire exposed length
- Coloring the exposed insulation or covering green
- Marking the exposed insulation or covering with green tape or green adhesive labels

Objective 10

Types and uses of cables found in the electrical field

a. Nonmetallic-sheathed cable (NM and NMC)

Note: Refer to *NEC* Article 334.

- Dry locations
- Majority of residential interior wiring

Note: The insulated conductors shall be one of the types listed in Table 310.13 suitable for branch circuit wiring or one identified for use in these cables. Conductors shall be rated 90°C (194°F). The ampacity of types NM and NMC cable shall be that of 60°C (140°F) conductors and shall comply with section 310.15.

b. Underground feeder and branch-circuit cable (UF)

Note: Refer to *NEC* Article 340.

- Dry and wet locations
- Suitable for burial

c. Service-entrance cable (SE and USE)

Note: Refer to *NEC* Article 338.

- Dry and wet locations
- Service-entrance conductors where applicable

d. Armored cable (AC)

Note: Refer to *NEC* Article 320.

- Dry locations
- Branch circuits and feeders in both exposed and concealed work

e. Mineral-insulated, metal-sheathed cable (MI)

Note: Refer to *NEC* Article 332.

- Dry and wet locations
- Service feeders and branch circuits

f. Power and control tray cable (TC)—Power, lighting, control, signal, and communication circuits

Note: Refer to *NEC* Article 336.

Objective 11

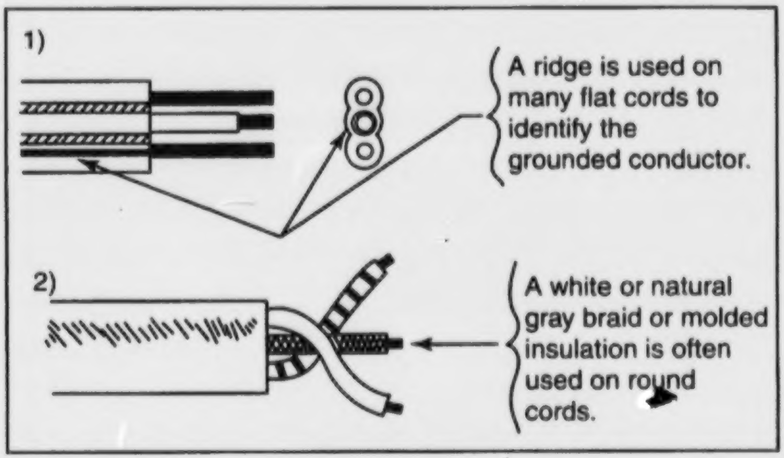
Cords and their conductors

Note: Refer to *NEC* Article 400

a. Cords used in a grounded system must have an identified grounded conductor.

Note: Grounded-conductor identification (a) through (f) describes acceptable methods for identifying grounded conductors.

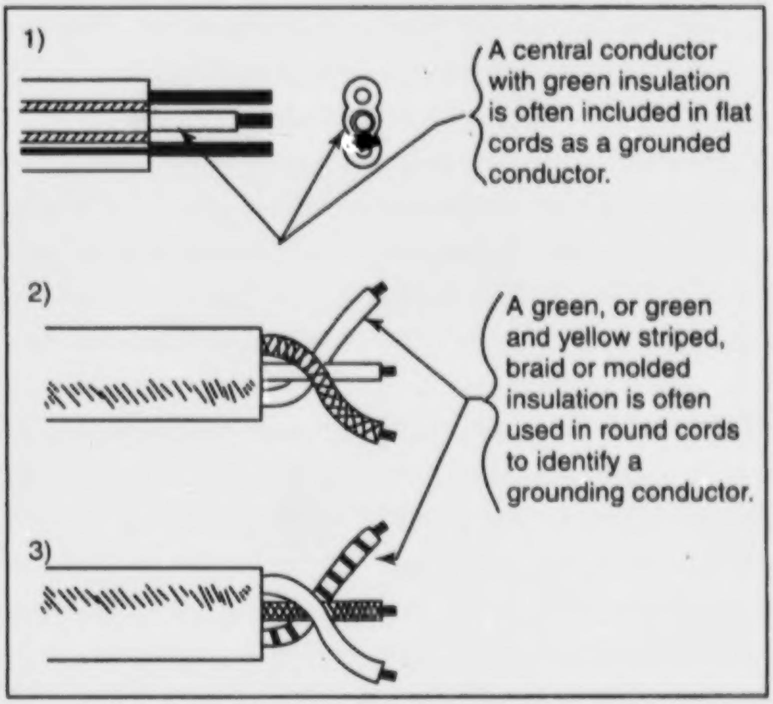
Figure 12


1)
A ridge is used on many flat cords to identify the grounded conductor.
2)
A white or natural gray braid or molded insulation is often used on round cords.

b. Cords that have a conductor with green, or green with yellow striped, insulation shall use that conductor for grounding purposes only.

Note: Refer to *NEC* Article 400.23.

Figure 13


1)
A central conductor with green insulation is often included in flat cords as a grounded conductor.
2)
A green, or green and yellow striped, braid or molded insulation is often used in round cords to identify a grounding conductor.
3)

c. Ungrounded conductors can be any color other than those designated for grounded or grounding conductors.

d. Cords should be used within their amp and insulation rating or classification.

Note: Refer to *NEC* Table 400.5.

Unit Contents

Student Components

Student Page

Learning Activities Sheet 14–3

Objective Sheet 14–5

Information Sheet 14–7

* Focus Assignment

List Licensing Requirements for Low Voltage Wiring Systems 137

* Assignment Sheets

1—Draw a Wiring Diagram Indicating the Proper Connection for Bell Circuit Equipment 139
2—Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors 141

* Job Sheets

1—Wire a Two-Button Chime Circuit 143
2—Wire Two Interconnecting Smoke Detectors 149

* Focus Assignment, Assignment Sheets and Job Sheets are located in Student Workbook 2.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "List Licensing Requirements for Low Voltage Wiring Systems."

☐ 4. **Study** Information Sheet, Objectives 1 through 4.

☐ 5. **Do** Assignment Sheet 1, "Draw a Wiring Diagram Indicating the Proper Connection for Bell Circuit Equipment."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat Steps 4 and 5.

☐ 7. **Do** Job Sheet 1, "Wire a Two-Button Chime Circuit."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 7.

☐ 9. **Study** Information Sheet, Objectives 4 through 10.

☐ 10. **Do** Assignment Sheet 2, "Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors."

☐ 11. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, repeat Steps 9 and 10.

☐ 12. **Do** Job Sheet 2, "Wire Two Interconnecting Smoke Detectors."

☐ 13. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 12.

☐ 14. **Study** Information Sheet, Objective 11.

☐ 15. **Check** With instructor for any additional assignments to be completed.

☐ 16. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 17. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to install low voltage wiring systems in a residence. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to low voltage wiring circuits with their correct definitions.
2. Identify the parts of a low voltage wiring system.
3. Describe the process that takes place during a low voltage lighting circuit off/on cycle.
4. Describe the process that takes place during the energizing of a chime circuit.
5. Complete a thermostat drawing of the manual fan switching circuit to indicate the current flow path through the fan control switch and fan relay.
6. Complete a thermostat drawing to indicate the current flow path with the thermostat system switch in the cool position and the fan switch on auto.
7. Complete a thermostat drawing to indicate the current flow path with the thermostat system switch in the heat position and the fan switch on auto.
8. Complete statements about anticipator circuits on low voltage thermostats.
9. Match communication circuits with their characteristics.
10. Complete statements about smoke and fire alarm systems.
11. Select true statements about the operation of a garage door opener.
12. List licensing requirements for low voltage wiring systems. (Focus Assignment)
13. Draw a wiring diagram indicating the proper connection for bell circuit equipment. (Assignment Sheet 1)
14. Draw a wiring diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors. (Assignment Sheet 2)
15. Wire a two-button chime circuit. (Job Sheet 1)
16. Wire two interconnecting smoke detectors. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Coaxial cable**—Conductor used for carrying communication signals

b. **Heat detectors**—A fire warning device commonly used in a residence; available in two types: fixed or rate-of-rise temperature detectors

c. **Momentary contact switch**—A switch that is closed or opened only while the operator touches it

d. **Pull-push solenoid**—Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has circuits applied to it

e. **Relay**—Electromagnetic device for remote or automatic control

f. **Smoke detector**—A fire warning device commonly used in a residence; available in two types: photoelectric or ionization

g. **Solenoid**—Electromagnetic cylinder that moves an iron plunger when current is applied

h. **Telephone system**—A personal communication system installed in the home to provide outside conversation with the world

i. **Thermostat**—A device that senses temperature variations from a set point and, in turn, acts to control a circuit

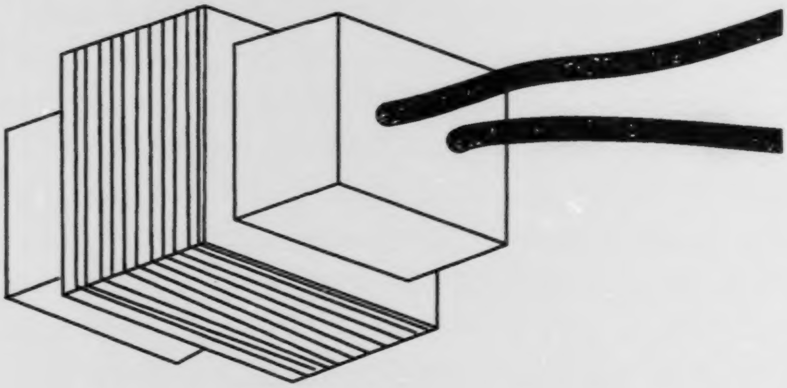
j. **Transformer**—An electrical device used to step up or step down a primary voltage to a desired secondary voltage

Objective 2

Parts of a low voltage wiring system

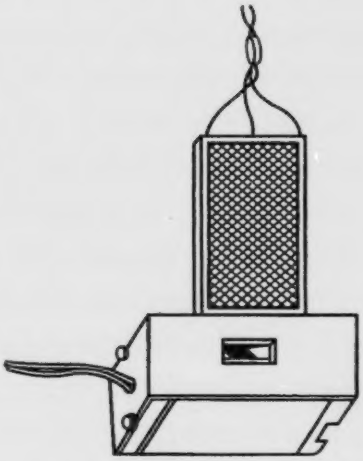
a. 24-volt transformer

Figure 1



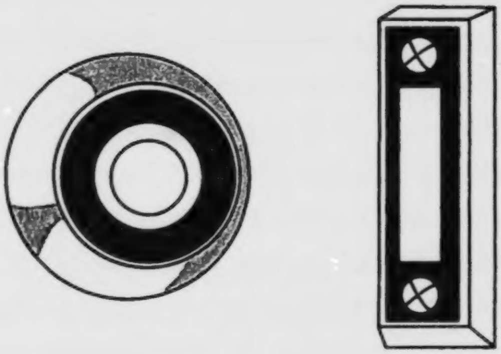
b. Low voltage lighting relay

Figure 2



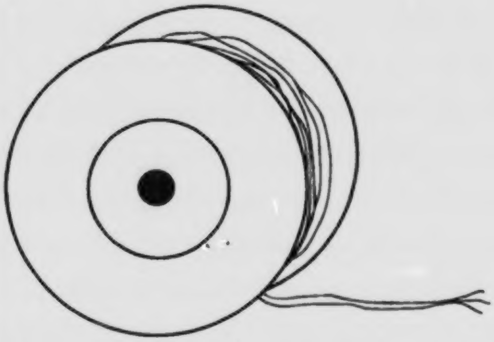
c. Momentary contact switch

Figure 3



d. Low voltage cable

Figure 4

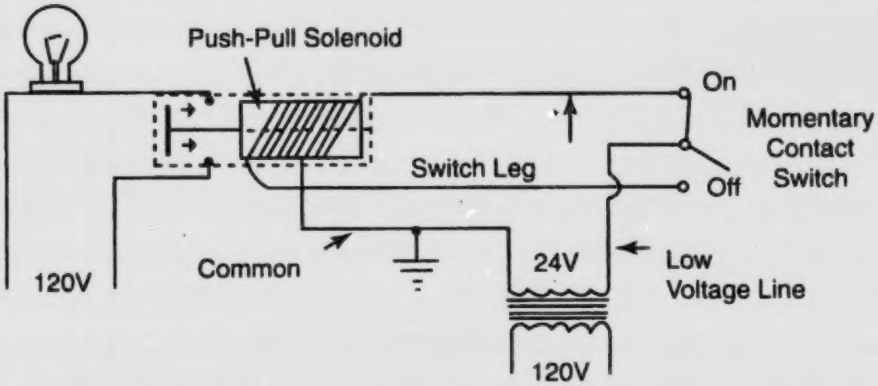


Objective 3

Low voltage lighting circuit off/on cycle

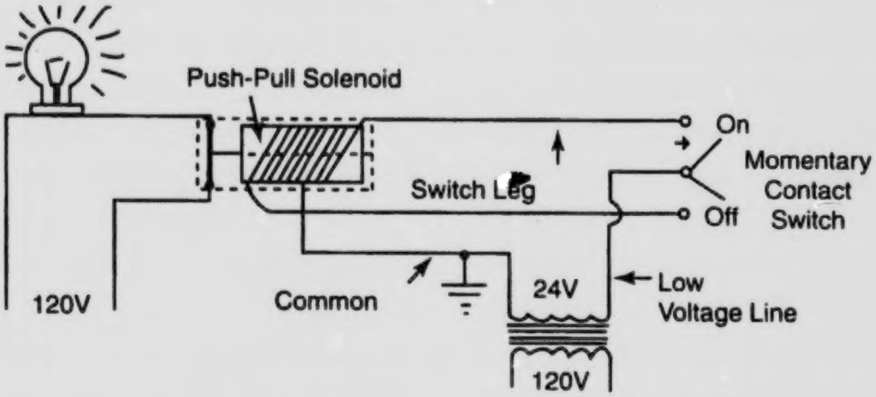
a. "On" switch is pushed.

Figure 5


Push-Pull Solenoid
On
Momentary
Contact
Switch
Switch Leg
Off
120V
Common
24V
Low
Voltage Line
120V

- Circuit is completed to closing movement of solenoid in relay. (Figure 6).
- Core is moved and circuit is completed.

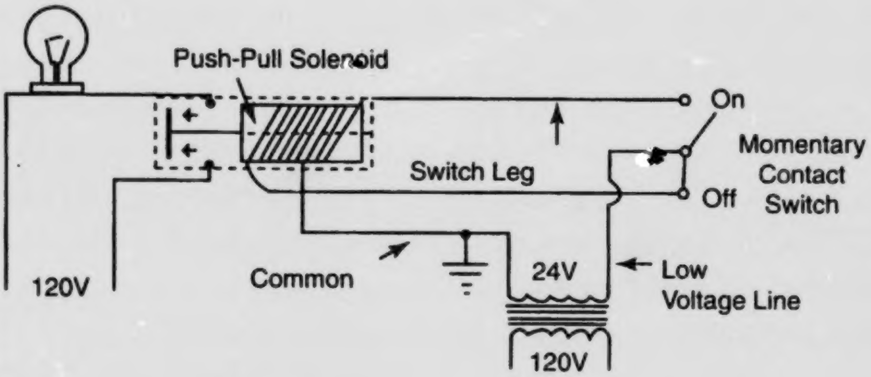
Figure 6


Push-Pull Solenoid
On
Momentary
Contact
Switch
Switch Leg
Off
24V
Low
Voltage Line
120V
Common
120V

b. "Off" switch is pushed.

- Circuit is completed to opening movement of solenoid in relay. (Figure 7)
- Core is moved and circuit is opened.

Figure 7


Push-Pull Solenoid
On
Momentary
Contact
Switch
Switch Leg
Off
24V
Low
Voltage Line
120V
Common
120V

Objective 4

Process that takes place during the energizing of a chime circuit

Note: This is a front door signal on a two-note chime.

a. Button is pushed.

- Circuit is completed to solenoid.
- Plunger is drawn down to chime and sound is made.

b. Button is released.

- Circuit is open.
- Spring pulls plunger up to upper chime and another sound is made.

Objective 5

Manual fan switching circuit

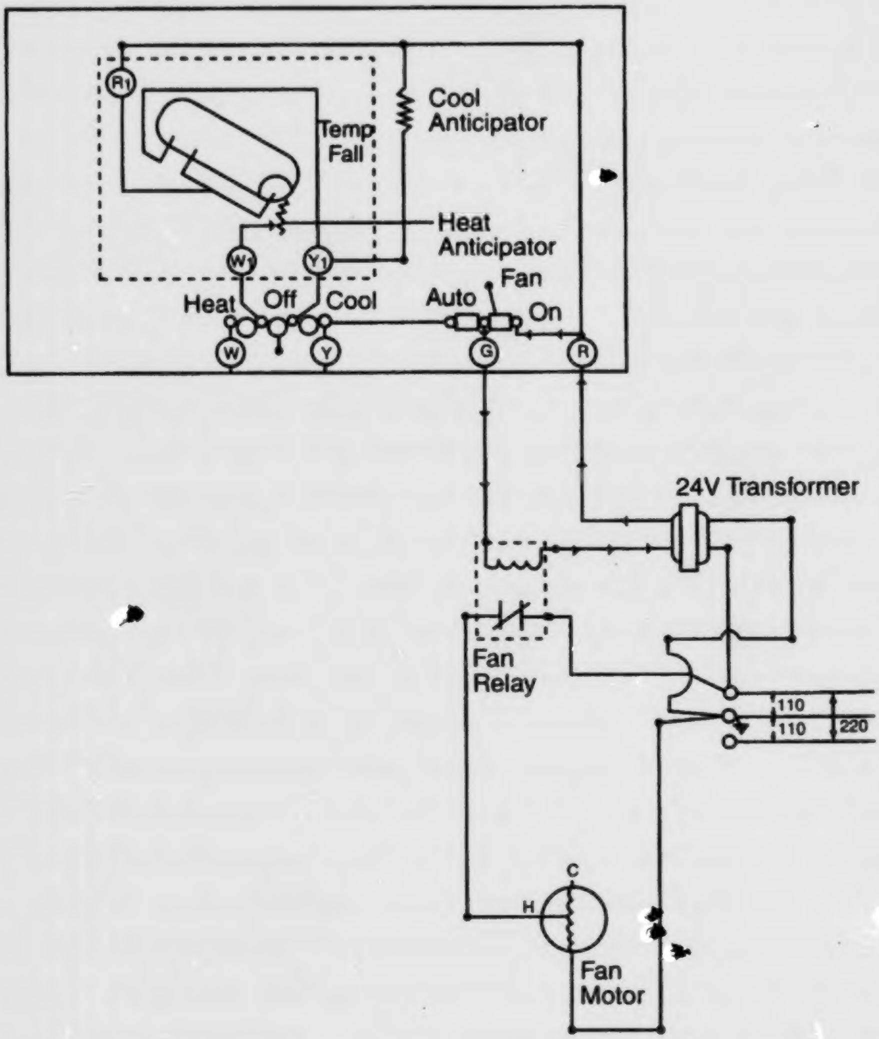
a. Current from transformer goes to fan control switch.

b. Closed switch directs current to fan relay control coil.

Note: This closes normally open contacts, and the fan motor receives line voltage and runs.

c. Common conductor returns current to transformer.

Figure [illegible]


R1
Cool
Anticipator
Temp
Fall
Heat
Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan
Relay
110
110
220
C
H
Fan
Motor

Objective 6

Thermostat system switch in cool position, fan switch on auto

a. Current from transformer goes to mercury bulb switch.

b. From mercury switch current goes to the system switch.

c. Current splits at the system switch.

- One split goes to fan switch.

  Note: Follow the arrow heads.

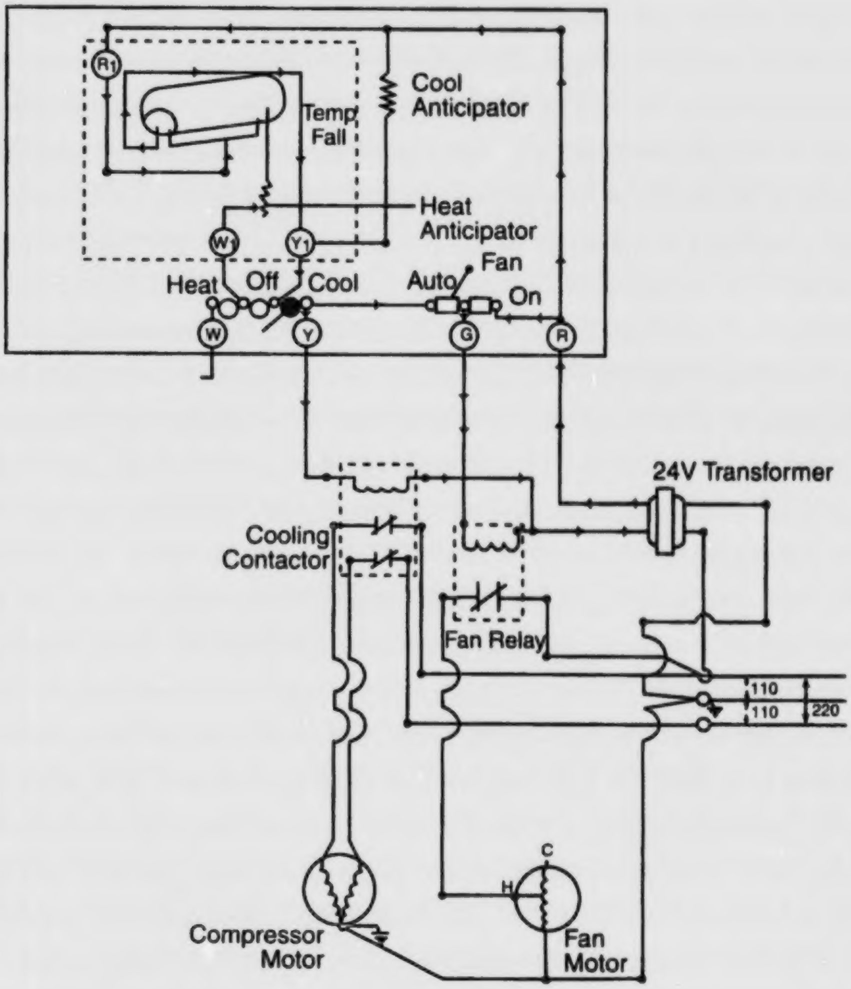
  — Through closed automatic contacts

  — To fan relay control coil

  Note: This closes normally open relay contacts and starts fan motor.

  — Back to transformer

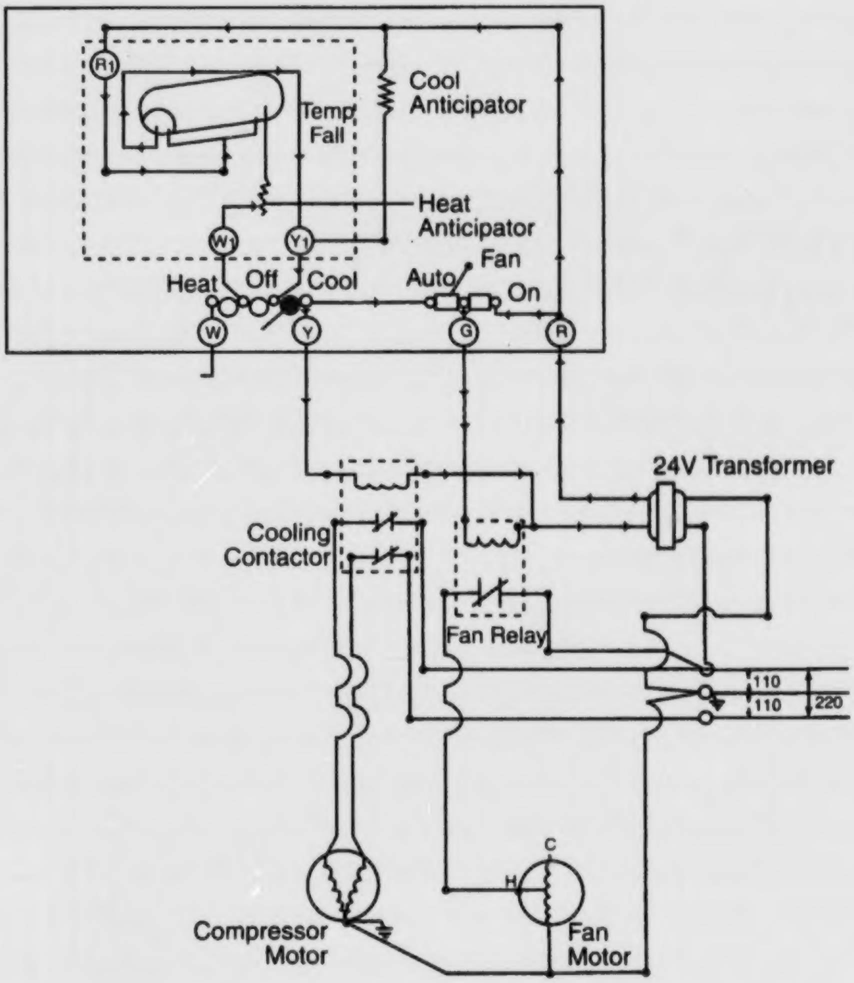
Figure 9


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

- One split goes to the cooling contactor.
  - Through cooling contactor coil

    Note: This closes normally open contacts and compressor starts.
  - Back to transformer

Figure 10


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Auto
On
Heat
Off
Cool
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

Objective 7

System switch in heat position

a. Current from transformer goes to mercury bulb switch,

b. Through mercury bulb switch to system switch,

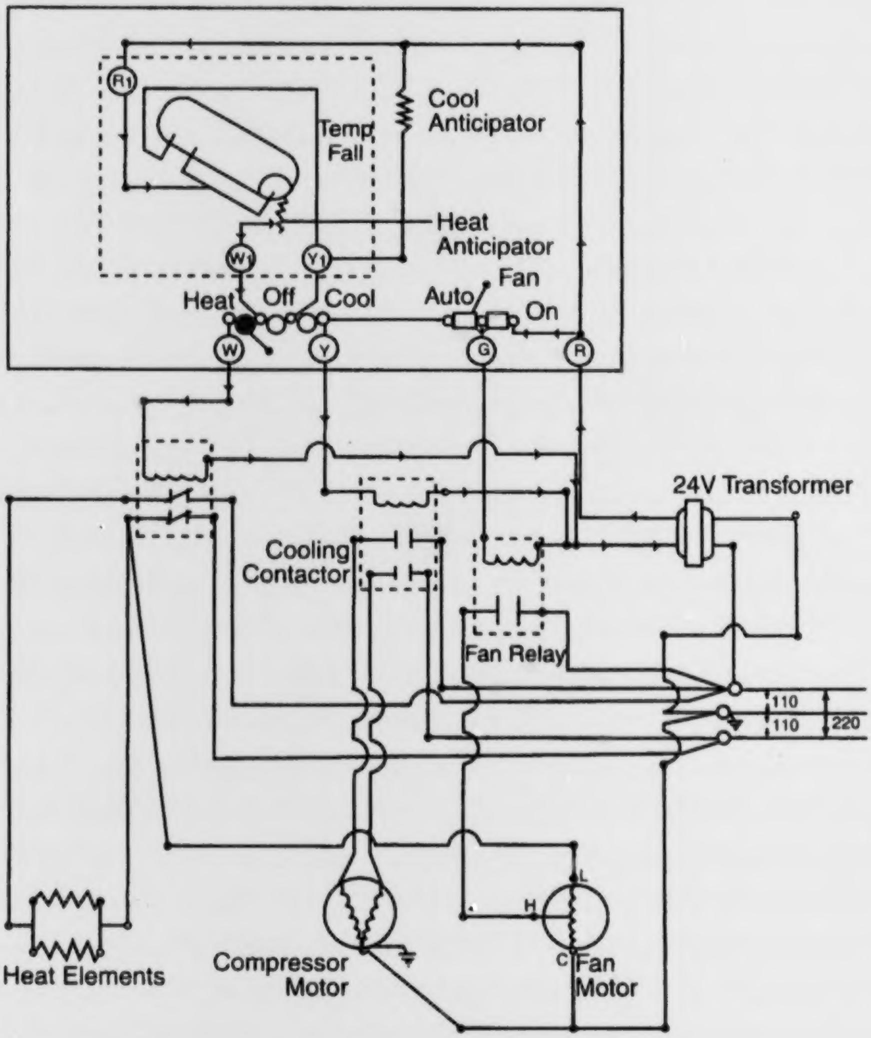
c. Through closed contacts of heat circuit,

d. To heating contactor or control valve coil, and

Note: This closes normally open relay contacts and energizes elements and low-speed fan control. On gas models, a plenum switch energizes the fan motor.

e. Back to transformer.

Figure 11


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

Objective 8

Anticipator circuits on low voltage thermostats

a. Heat and cool anticipators are installed to compensate for bimetallic lag.

b. Cool anticipator

Note: These are usually fixed resistors.

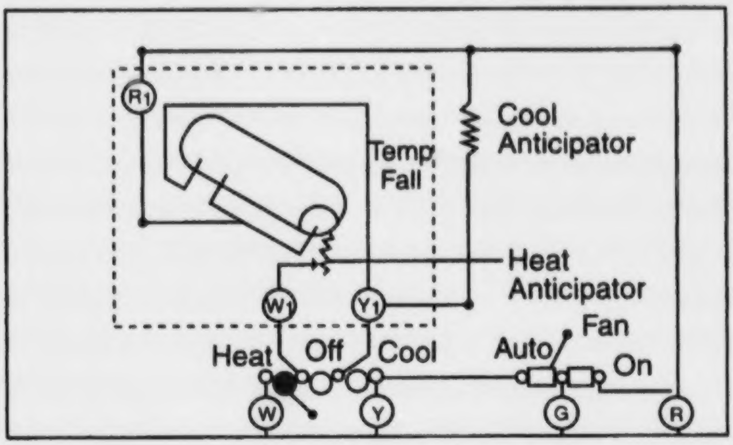
- It is wired parallel to mercury switch.
- Current draw through the resistor causes heat.
- Heat causes bimetal to tilt bulb and close circuit before room temperature actually reaches "on" temperature setting.

c. Heat anticipator

Note: These are usually variable resistors.

- It is wired in series with mercury switch.
- Current draw through switch causes heat.
- Heat causes bimetal to tilt bulb and open circuit before room temperature reaches desired room setting.

Figure 12



Objective 9

Communication circuits and their characteristics

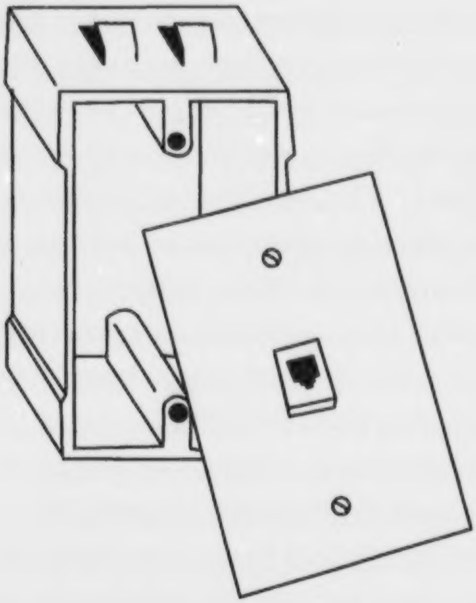
Note: All equipment must be UL listed.

a. Telephone

- The point where the local telephone's wiring ends and the home owner's interior wiring begins is called the "demarkation point."
- The telephone wiring inside the home must comply to the rules in Article #800 of the *NEC*.

- The most common telephone wiring for a new home or existing home extensions is a 4-conductor #22 or #24 cable.
- The common terms for telephone cable is: two pair—4 conductors, three pair—6 conductors, twelve pair—24 conductors, etc.
- Telephone circuits require a separate pair of conductors from the telephone all the way back to the phone company's switching center.
- For new construction installations, standard electrical boxes are used at telephone outlet locations. These boxes will support wall phones or modular plates.

  Figure 13



- The two types of standard telephone wiring methods are individual cables run to each telephone outlet or a complete loop system.

  Note: With the loop system, should anything happen to one section of the cable, the circuit can be fed from the other direction.

- All telephone hook-ups are wired in a parallel pattern.

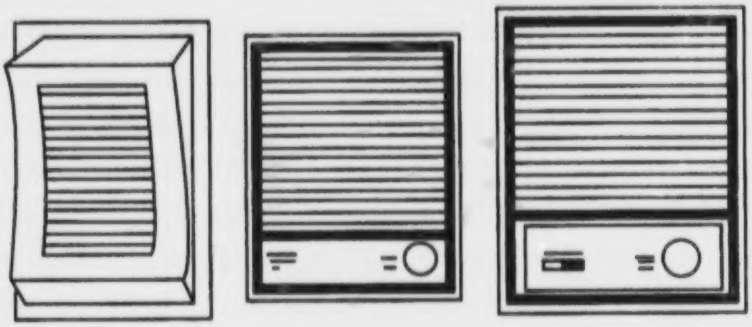
  Note: *NEC*, Art. 800 covers installation requirements for phone systems. Local telephone companies may also have additional requirements. There is little danger of electrical shock from the telephone's own voltage when the phone is not ringing (only 48-volt DC is present). The operation of the phone signaling device (ringing) requires 85- to 90-volt AC. This voltage is supplied by the telephone company. If contact is made with this higher AC voltage, it can be uncomfortable but not harmful. To avoid electrical shock, take the receiver off the hook when working on the system.

b. Intercom system

- This low voltage wiring system allows one-way monitoring or two-way conversation communication throughout the residence.
- Most systems today also incorporate radio and tape through the system speakers.
- The system also provides added security with door answering communications without opening your door to a stranger.

Note: Shown below are typical system components.

Figure 14



c. Television antenna

- The television antenna and Community Antenna Television (CATV or Cable) system installed in the home is regulated by Art. 820 of the *NEC*.
- Television cable is available in two basic types: twin lead (300 ohms) and coaxial (75 ohms).
- All television cable systems must be grounded.
- If a separate grounding electrode is used, other than a service grounding electrode, the two electrodes must be bonded.

Objective 10

Smoke and fire alarm systems

Note: *NEC* Article 760 pertains to requirements for fire protection signalling systems.

a. Heat and smoke detectors installed in a residence give people early warning of the presence of fire.

Note: Fire is the third leading cause of accidental fatalities. Home fires account for the biggest share of the deaths; most occur at night when people are asleep. Heat and smoke detectors are available in single or multi-installation types.

b. Two types of fire warning device commonly used in residences are heat detectors and smoke detectors.

c. Heat detectors sense a specific fixed temperature, such as 135°F or 200°F, or a rate-of-rise (12 to 15 degrees per minute), such as rises caused by flash fires.

d. The two most common types of smoke detectors are:

- **Photoelectric**—This detector has a light sensor that measures the amount of light in a chamber. Smoke reduces the amount of light and an alarm is sounded.

  Note: This type of detector is most useful in situations where burning materials, such as rags, mattresses, and furniture create great quantities of smoke.

- **Ionization**—This detector has a source of particles that ionize the air in the chamber. Inside the chamber are two plates of opposite charge. The ionized air conducts a small current (millionths of an ampere) between the plates. Smoke entering this chamber restricts the current flow causing an alarm to sound.

  Note: This type of detector is most useful in situations where burning materials, such as gasoline or alcohol, create very small amounts of smoke.

Objective 11

Operation of a garage door opener

a. The opener contains a motor, gear reduction unit, motor reversing switch, transformer, and electric brake. All of the components are preassembled.

b. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers (remote control).

c. The push-button or key operated station consists of a normally-open momentary contact switch connected by 2-wire, low voltage cable to the control unit. A photoelectric sensor system is also connected to the control unit by low voltage cable to insure a clear path for the door to travel. Actuation of switches causes the step relay to close, energizing the motor in the opposite direction of its previous travel.

d. The radio-controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency (from the remote-control device) it will energize the motor in the opposite direction of its previous travel.

Unit Contents

Student Components

Student Page

Learning Activities Sheet 15–3

Objective Sheet 15–5

Information Sheet 15–7

* Focus Assignment

Identify Overcurrent Protective Devices 153

* Assignment Sheet

1—Calculate Conductor and Fuse Sizes 155

* Job Sheet

1—Test Cartridge Fuses 157

* Focus Assignment, Assignment Sheet and Job Sheet are located in Student Workbook 2.

Unit 15 Overcurrent Protection

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "Identify Overcurrent Protective Devices."

Optional

☐ 4. **View** Videotape entitled "Ground Fault Circuit Interrupter."

☐ 5. **Study** Information Sheet, Objectives 1 through 9.

☐ 6. **Do** Assignment Sheet 1, "Calculate Conductor and Fuse Sizes."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 and 6.

☐ 8. **Do** Job Sheet 1, "Test Cartridge Fuses."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 8.

☐ 10. **Check** With instructor for any additional assignments to be completed.

☐ 11. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 12. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to choose and install proper overcurrent protective devices. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to overcurrent protection with their definitions.
2. List seven types of overcurrent protective devices.
3. Describe the operation of a single-element fuse.
4. Describe the operation of a dual-element, time-delay fuse.
5. Distinguish between types of circuit breakers and their operation.
6. Select true statements about requirements for fuses of less than 600 volts.
7. Complete statements about requirements for circuit breakers of less than 600 volts.
8. List installations that require GFCI protection.
9. List the installation requiring AFCI protection.
10. Identify overcurrent protective devices. (Focus Assignment)
11. Calculate conductor and fuse sizes. (Assignment Sheet 1)
12. Test cartridge fuses. (Job Sheet 1)

Information Sheet

Objective 1

Terms and definitions

a. **Air circuit breaker**—Breaker in which all parts operate in air

b. **Amperage rating**—Maximum current-carrying capacity of a device

c. **Arc-fault circuit interrupter**—A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected

d. **Blade-type cartridge fuse**—Fuse with flat contact blades on a cylindrical case

e. **Circuit breaker**—A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating

f. **Current-limiting overcurrent protective device**—Device that, when interrupting current in its current-limiting range, reduces the short-circuit current flowing in the faulted circuit to substantially less than would otherwise flow into the fault

g. **Device**—A unit of an electrical system that is intended to carry but not utilize electric energy

h. **Dual-element fuse**—Fuse that has within it a thermal cutout element with a time delay that permits momentary harmless inrush currents to flow without harming the fuse

Note: Dual-element fuses should not be confused with fuses with two renewable links in a fuse cartridge.

i. **Edison-base plug fuse**—Fuse with a base that fits the same socket as a regular based incandescent bulb

j. **Fault current**—Current that flows from one conductor to ground or another conductor because of an abnormal connection or arc between the two

k. **Ferrule-type cartridge fuse**—Fuse with metal caps on a cylindrical case

l. **Ground fault**—Accidental connection between an electrical circuit or equipment and the earth or some conducting body that serves in place of the earth

m. **Ground-fault circuit-interrupter**—A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time, when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit

n. **Interrupting rating**—Maximum available short-circuit current that an overcurrent device can safely interrupt without damage to itself

o. **Oil circuit breaker**—Load interrupter in which the interrupting contacts operate submerged in transformer oil

p. **Overcurrent**—Any current in excess of the rated current of the equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault

q. **Overload**—Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload

r. **Selective coordination**—The use of interrupting devices sized and installed so that the one nearest the fault or overloaded machine will open before any of the larger upstream devices open

s. **Single-element fuse**—Fuse that contains only one element and is not designed to carry an overload

t. **Time current curve**—Plotted curve showing how long a fuse or breaker will carry an overload before opening the circuit

u. **Type "S" plug fuse**—Fuse with special size-limiting characteristics for each amperage range

Note: Refer to *NEC* Article 240.53.

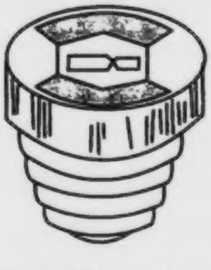
v. **Voltage rating**—Maximum voltage at which a device is designed to operate

Objective 2

Type of overcurrent protective devices

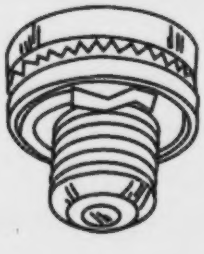
a. Edison-base plug fuse

Figure 1



b. Type "S" plug fuse (fustat)

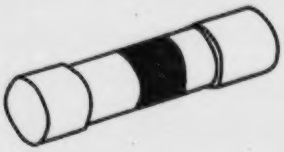
Figure 2



c. Ferrule-type cartridge fuse

Note: Standard ampacities are 15, 20, 30, 40, and 60 amps.

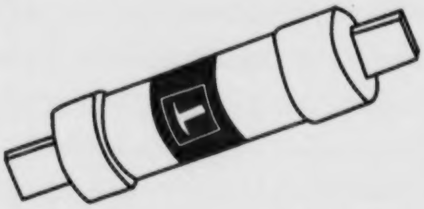
Figure 3



d. Blade-type cartridge fuse

Note: Standard ampacities start at 65 amps.

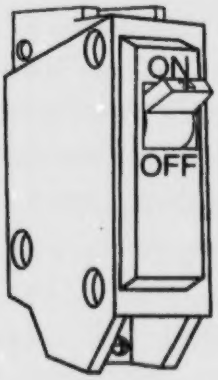
Figure 4



e. Circuit breaker

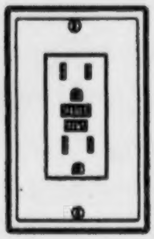
Note: Standard ampacities start at 15 amps

Figure 5



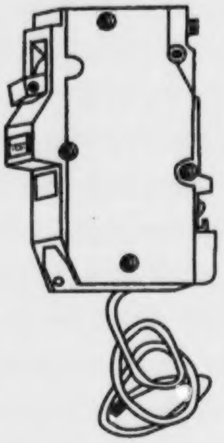
f. Ground fault circuit interrupter receptacle

Figure 6



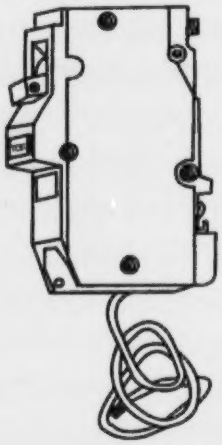
g. Ground fault circuit interrupter breaker

Figure 7



h. Arc fault circuit interrupter (AFCI) Breaker

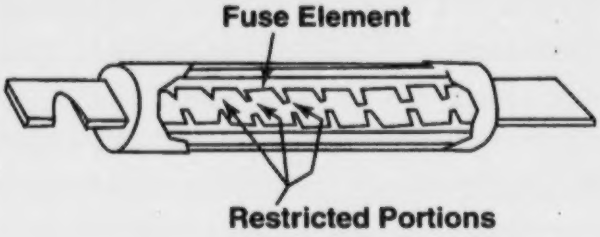
Figure 8



Objective 3

Operation of a single-element fuse—Under sustained overload conditions, the restricted portions of the fuse element heat to their predetermined melting point, thus opening and interrupting the flow of current.

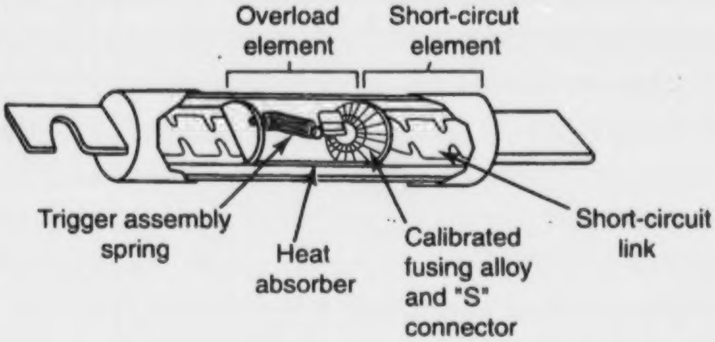
Figure 9


Fuse Element
Restricted Portions

Objective 4

Operation of a dual-element, time-delay fuse—Under sustained overload conditions, the trigger spring fractures the fusing alloy and releases the "S" connector.

Figure 10


Overload element
Short-circut element
Trigger assembly spring
Heat absorber
Calibrated fusing alloy and "S" connector
Short-circuit link

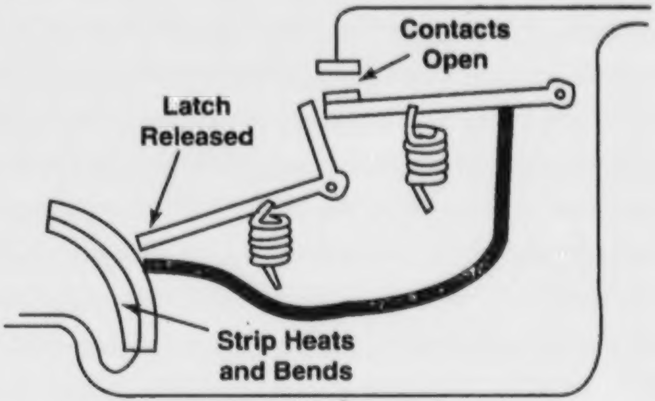
Objective 5

Types of circuit breakers and their operation

a. Thermal trip

- If current flow exceeds the rated limit of the breaker, the bimetallic strip heats and bends.
- As the strip bends, the latching mechanism is tripped and the contacts open.

Figure 11

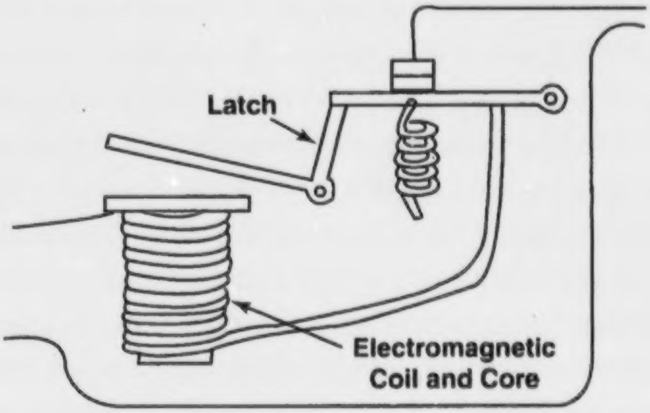

Contacts Open
Latch Released
Strip Heats and Bends

Reprinted with permission of NUS Training corporation.

b. Electromagnetic trip

- As current flows through the breaker, ti creates a magnetic field within the coil. During sustained overload conditions, the magnetic field interferes and draws the core into the coil.
- The metal trip bar is attracted to the core forcing the latch to move, thus opening the contacts.

Figure 12


Latch
Electromagnetic Coil and Core

Reprinted with permission of NUS Training corporation.

Objective 6

Requirements for fuses of less than 600 volts

Note: Refer to *NEC* Article 240.

a. Plug fuses shall not be used in circuits exceeding 125 volts between conductors.

b. Fuses shall be marked with their amperage rating.

c. Plug fuses shall be classified 0 to 30 amperes.

d. Edison-base plug fuses shall only be used for replacement in existing installations where there is no evidence of overfusing or tampering.

e. Type "S" fuses (fustats) shall be classified at not over 125 volts.

Note: Refer to *NEC* Article 240.53(A)

f. Type "S" fuses shall be classified as 0 to 15, 16 to 20, and 21 to 30 amperes.

g. Different ampere classes of type "S" fuses are not interchangeable.

h. Cartridge fuses shall be marked with their amperage rating, voltage rating, and the name or trademark of the manufacturer.

Objective 7

Requirement for circuit breakers of less than 600 volts

Note: Refer to *NEC* Article 240.

a. Circuit breakers shall be capable of being manually tripped and set.

Note: Where used as switches in 120- and 277-volt fluorescent lighting circuits, breakers shall be approved for such switching duty and shall be marked "SWD."

b. Circuit breakers shall clearly indicate whether they are in the open "off" or closed "on" position.

c. The breaker shall be designed so that any change of its trip point (calibration) or time required for operation will require dismantling or the breaking of a seal.

d. Circuit breakers shall be marked with their ampere rating in a manner that will be durable and visible by removal of a trim or cover.

e. Every circuit breaker having an interrupting rating other than 5,000 amperes shall have its interrupting rating shown on the circuit breaker.

Objective 8

Installations that require GFCI protection

a. All 125-volt, single-phase, 15- and 20 ampere receptacles that are not part of the permanent wiring on construction sites

b. All 125-volt, single-phase, 15- and 20 ampere receptacles installed in bathrooms

c. All 125-volt, single-phase, 15- and 20 ampere receptacles installed in garages

d. All 125-volt, 15- and 20 ampere receptacles installed outdoors

e. All 125-volt, 15- and 20 ampere receptacles in crawl spaces at or below grade level and in unfinished basements

f. All 125-volt, 15- and 20 ampere receptacles within 6 feet of a wet bar sink or kitchen sink that serves counter top surfaces

g. All 125-volt, 15- and 20 ampere receptacles installed in boathouses

h. All 125-volt, 15- and 20-ampere receptacles installed in bathrooms of commercial, industrial, and all nondwelling occupancies

i. All 125-volt, 15- and 20-ampere receptacles installed on roofs

j. Lighting fixtures and lighting outlets installed in the area extending between 5 feet and 10 feet horizontally from the inside walls of a pool, unless installed 5 feet above maximum water level and rigidly attached to structure adjacent to or enclosing the pool

k. All 125-volt, 30 ampere receptacles used for temporary wiring

l. Agricultural buildings in an equipotential plane area

m. Some 125-volt, 15 and 20 ampere receptacles for carnival and similar events

n. Large self-contained tubs and pools

Objective 9

Installations that require AFCI protection

a. All 125-volt, 15- and 20-amp outlets in dwelling unit bedrooms. 210.12(B)

Unit Contents

Student Components

Student Page

Learning Activities Sheet 16–3

Objective Sheet 16–5

Information Sheet 16–7

* Focus Assignment

Determine Cost of Load Center Construction 159

* Assignment Sheet

1—Using the *NEC*, Answer Questions Related to Load Centers .. 161

* Job Sheets

1—Install a Safety Switch 163
2—Wire a Load Center or Breaker Panel 165
3—Wire a Receptacle Circuit to a Load Center 169

* Focus Assignment, Assignment Sheet and Job Sheets are located in Student Workbook 2.

Unit 16 Load Centers and Safety Switches

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "Determine Cost of Load Center Construction."

☐ 4. **Study** Information Sheet, Objective 1.

☐ 5. **Do** Assignment Sheet 1, "Using the *NEC*, Answer Questions Related to Load Centers."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat Steps 4 and 5.

☐ 7. **Study** Information Sheet, Objectives 2 and 3.

☐ 8. **Do** Job Sheet 1, "Install a Safety Switch."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 8.

☐ 10. **Study** Information Sheet, Objectives 4 through 9.

☐ 11. **Do** Job Sheet 2, "Wire a Load Center or Breaker Panel."

☐ 12. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 13. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 11.

Learning Activities Sheet

☐ 13. **Do** Job Sheet 3, "Wire a Receptacle Circuit to a Load Center."

☐ 14. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 15. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 13.

☐ 15. **Check** With instructor for any additional assignments to be completed.

☐ 16. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 17. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify parts and components of load centers and safety switches as well as install them. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to load centers and safety switches with their definitions.
2. Identify types of safety switch enclosures.
3. Identify safety switch system configurations.
4. Identify types of load centers and enclosures.
5. Match common load center accessories with their uses.
6. Label the parts of a fusible, single-phase load center.
7. Label the parts of a breaker load center.
8. Identify common panel bus configurations.
9. Select true statements about safety rules for working near load centers and safety switches.
10. Determine cost of load center construction. (Focus Assignment)
11. Using the *NEC*, answer questions related to load centers. (Assignment Sheet 1)
12. Install a safety switch. (Job Sheet 1)
13. Wire a load center or breaker panel. (Job Sheet 2)
14. Wire a receptacle circuit to a load center. (Job Sheet 3)

Information Sheet

Objective 1

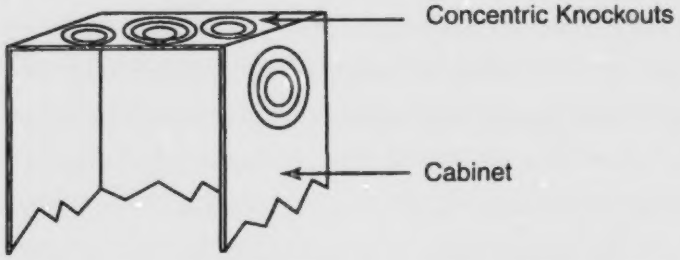
Terms and definitions

a. **Cabinet**—An enclosure designed either for surface or flush mounting and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung

b. **Concentric knockout**—Several removable metal rings that allow for the entrance of various standard sizes of connectors into a cabinet (Figure 1)

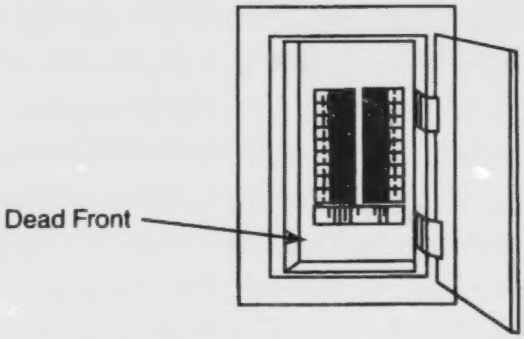
Note: Standard concentric knockout sizes are 1/2 inch, 3/4 inch, 1 inch, 1 1/4 inches, 1 1/2 inches, 2 inches, and 2 1/2 inches.

Figure 1



c. **Dead front**—Removable cover used to prevent exposure of live parts to persons on the operating side of the equipment (Figure 2)

Figure 2



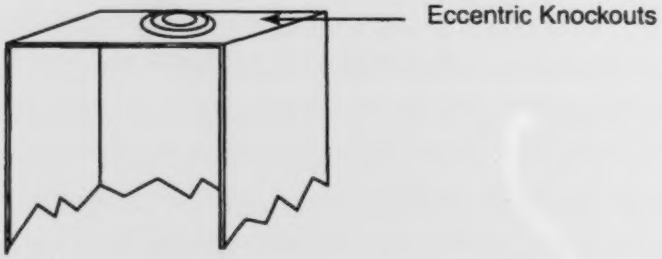
d. **Disconnecting means**—A device or group of devices, or other means, by which the conductors of a circuit can be disconnected from their source of supply

e. **Dustproof**—So constructed or protected that dust will not interfere with its successful operation

f. **Dust-tight**—So constructed that dust will not enter the enclosing case

g. **Eccentric knockout**—Knockout that is removed in sections to form larger holes (Figure 3)

Figure 3



h. **NEMA (National Electrical Manufacturer's Association)**—Organization responsible for setting specifications for various classes of enclosures

i. **NEMA Type 1**—General purpose enclosure for use indoors under usual service conditions

j. **NEMA Type 2**—Driptight enclosure used indoors to exclude falling moisture and dirt

k. **NEMA Type 3**—Weather resistant (weatherproof) enclosures suitable for indoor or outdoor use; will exclude falling dirt, light liquid splashing, rain, snow, sleet, and windblown dust

Note: Descriptors placed after the code number specify the suitable applications. A NEMA Type 3R is a common residential outdoor enclosure. The R stands for raintight and signifies that the enclosure will not exclude windblown dust.

l. **NEMA Type 4**—Watertight and dustproof enclosure suitable for areas where a great amount of splashing occurs, such as hose down areas

m. **NEMA Type 5**—Dust-tight enclosure not suitable for use around water

Note: All NEMA Type 12 enclosures and JIC (Joint Industry Conference) enclosures are suitable for NEMA Type 5 applications.

n. **NEMA Type 12**—Industrial use enclosure designed to exclude oil, coolant, flying dust and lint, and falling dirt

o. **Rainproof**—So constructed, protected, or treated as to prevent rain from interfering with successful operation of the apparatus

p. **Raintight**—So constructed or protected that exposure to a beating rain will not result in the entrance of water

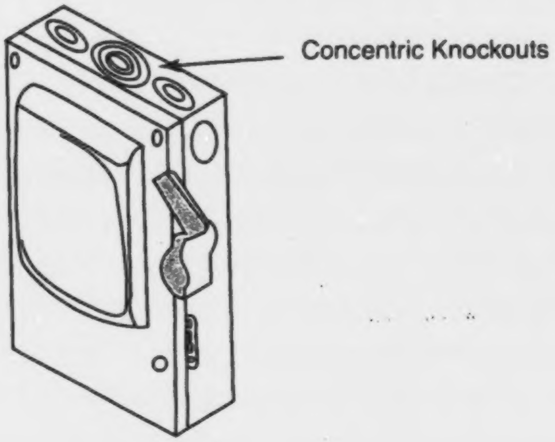
Objective 2

Types of safety switch enclosures

a. NEMA 1 (indoor)

Note: NEMA 1 safety switch enclosures may be easily identified because of the presence of concentric knockouts on the top of the enclosure.

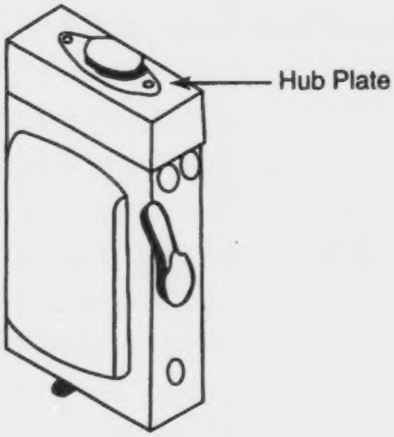
Figure 4



b. NEMA 3R (rainproof)

Note: NEMA 3R safety switch enclosures may be easily identified by the presence of a hub plate on the top of the safety switch.

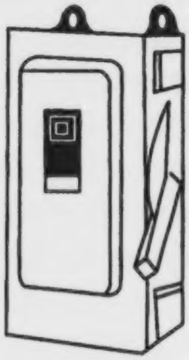
Figure 5



c. NEMA 4X (watertight, corrosion resistant)

Note: NEMA 4 X enclosures are generally constructed of stainless steel.

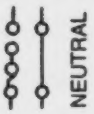
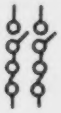
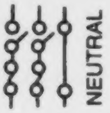
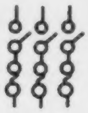
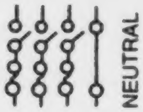
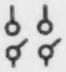
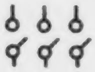
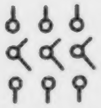
Figure 6



Objective 3

Safety switch system configurations

Figure 7

 2-wire S/N 1 blade, 1 fuse	 2-wire 2 blades, 2 fuses	 3-wire S/N 2 blades, 2 fuses
 3-pole fusible S/N	 4-wire S/N 3 blades, 3 fuses	 2-pole nonfusible 2 blades
 3-pole nonfusible	 3-pole, double-throw	

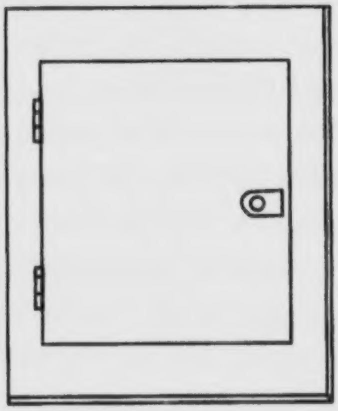
*S/N designates "solid neutral."

Objective 4

Types of load centers and enclosures

a. Flush mount (NEMA 1)

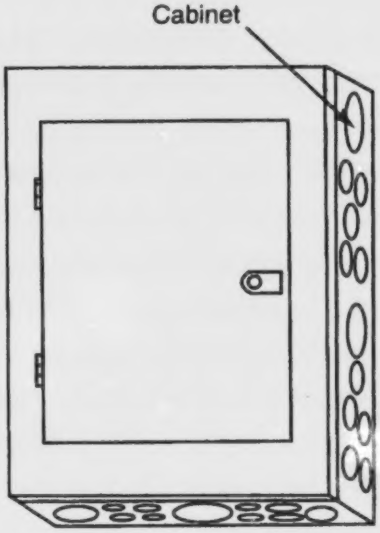
Figure 8



b. Surface mount (generally NEMA 1)

Note: In most cases surface-mount and flush-mount load centers use the same cabinets; however, other cabinets may be ordered for special installations.

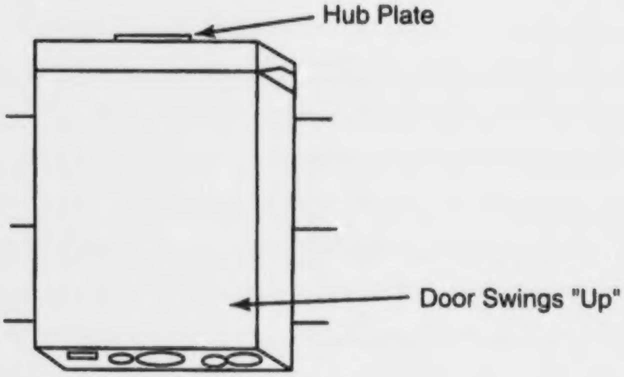
Figure 9



c. Exterior surface (NEMA 3R)

Note: NEMA 3R load center enclosures are identified by the presence of a hub plate on the top.

Figure 10

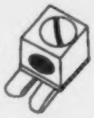


Objective 5

Load center accessories and their uses

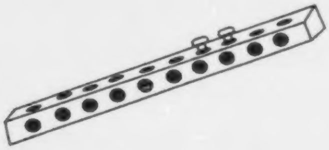
a. Lug—Used for termination of conductors

Figure 11



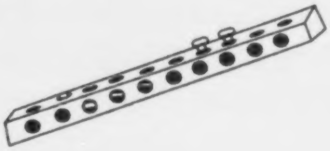
b. Grounded (neutral) bar—Used for termination of circuit grounded conductors

Figure 12



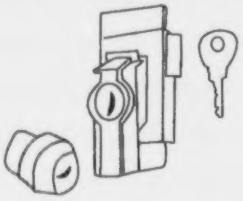
c. Grounding bar—Used for termination of equipment grounding conductors

Figure 13



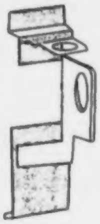
d. Flush locks—Used for locking of cabinet doors to allow entrance of qualified personnel only

Figure 14



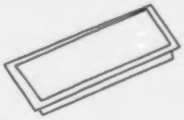
e. Padlock attachment—Used to lock breakers in the "off" or "on" position

Figure 15



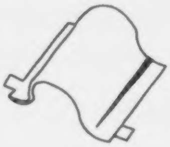
f. Closure plate—Used to fill empty breaker spaces where "breakouts" have been removed

Figure 16



g. Lock off—Used to lock breakers in the "off" position for equipment maintenance or servicing

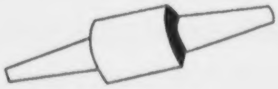
Figure 17



830

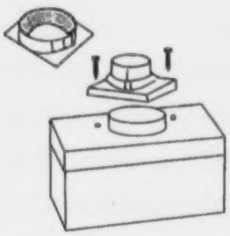
h. Handle tie—Used to mechanically tie two or more breaker handles together to assure common tripping

Figure 18



i. Conduit hubs—Used to allow entrance of conduits to rain-proof enclosures

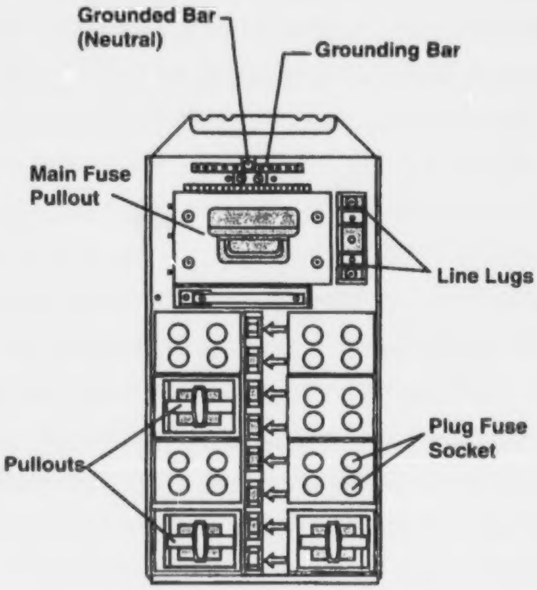
Figure 19



Objective 6

Parts of a fusible load center

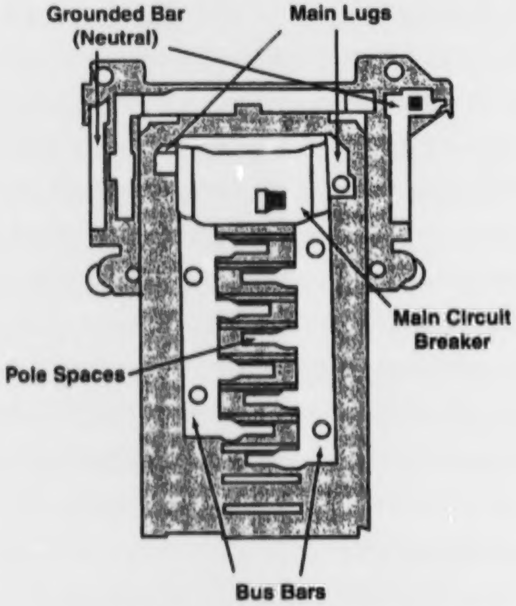
Figure 20


Grounded Bar
(Neutral)
Grounding Bar
Main Fuse
Pullout
Line Lugs
Plug Fuse
Socket
Pullouts

Objective 7

Parts of a breaker load center

Figure 21

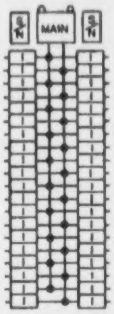

Grounded Bar (Neutral)
Main Lugs
Main Circuit Breaker
Pole Spaces
Bus Bars

Objective 8

Common panel bus configurations (Figure 22-25)

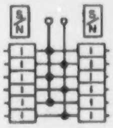
a. Main breaker single-phase

Figure 22



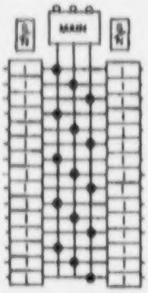
b. Main lug only (MLO) single-phase

Figure 23



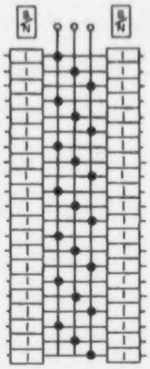
c. Main breaker three-phase

Figure 24



d. Main lug only (MLO) three-phase

Figure 24



Objective 9

Safety rules for working near load center and safety switches

a. Do not tamper with or alter equipment.

b. Install for intended purpose.

c. Install according to *NEC*.

d. Do not hold extra tools in your hand during installation or maintenance.

e. Stand to the side of a disconnect before energizing it.

Unit 17 Existing Structures

Unit Contents

Student Components

Student Page

Learning Activities Sheet 17–3

Objective Sheet 17–7

Information Sheet 17–9

* Assignment Sheet

1—Determine the Number of Conductors Allowed to Be Added to an Existing Conduit 173

* Job Sheets

1—Install a metallic box with dry-wall grips in a plasterboard wall 175
2—Secure a box with dry-wall supports (box tins) 179
3—Install a plastic box with dry-wall grips in a plasterboard wall 183
4—Install a box in a paneled wall 187
5—Install a box in a concrete block wall 191
6—Install a box in a brick wall 195
7—Install a box in a ceiling with an accessible attic 201
8—Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind bare board 205
9—Install cable between an existing box and a newly installed box, using an underfloor crawl space 209
10—Install cable between an existing box and a newly installed box, using attic space 213

* Assignment Sheet and Job Sheets are located in Student Workbook 2.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 5.

☐ 4. **Do** Job Sheet 1, "Install a Metallic Box with Dry-Wall Grips in a Plasterboard Wall."

☐ 5. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 6. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Steps 4.

☐ 6. **Do** Job Sheet 2, "Install a Box with Dry-Wall Supports (box tins)."

☐ 7. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 8. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 6.

☐ 8. **Do** Job Sheet 3, "Install a Plastic Box with Dry-Wall Grips in a Plasterboard Wall."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 8.

☐ 10. **Do** Job Sheet 4, "Install a Box in a Paneled Wall."

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 12. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Steps 10.

☐ 12. **Do** Job Sheet 5, "Install a Box in a Concrete Block Wall."

☐ 13. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 14. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat Step 12.

☐ 14. **Do** Job Sheet 6, "Install a Box in a Brick Wall."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 16. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 6 and repeat Step 14.

☐ 16. **Do** Job Sheet 7, "Install a Box in a Ceiling with an Accessible Attic."

☐ 17. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 18. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 7 and repeat Step 16.

☐ 18. **Do** Job Sheet 8, "Install Cable Between an Existing Box and a Newly Installed Box Horizontally Along a Wall in a Channel Behind Bare Board."

☐ 19. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 20. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 8 and repeat Step 18.

☐ 20. **Do** Job Sheet 9, "Install Cable Between an Existing Box and a Newly Installed Box, Using an Underfloor Crawl Space."

☐ 21. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 22. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 9 and repeat Step 20.

☐ 22. **Do** Job Sheet 10, "Install Cable Between an Existing Box and a Newly Installed Box, Using Attic Space."

☐ 23. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 24. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 10 and repeat Step 22.

☐ 24. **Study** Information Sheet, Objectives 6 through 10.

☐ 25. **Do** Assignment Sheet 1, "Determine the Number of Conductors Allowed to be Added to an Existing Conduit."

☐ 26. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 27. If the evaluation is not satisfactory, repeat Steps 24 and 25.

☐ 27. **Check** With instructor for any additional assignments to be completed.

☐ 28. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 29. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to determine the number of conductors allowed in an existing conduit and install additional box locations and cable runs in existing structures. The student should demonstrate these competencies by completing the assignment sheets, job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to existing structures with their definitions.
2. Identify construction members common in existing structures.
3. List four common routes for new cable installations in existing structures.
4. Complete a list of possible methods for getting cable through or around construction members.
5. List five wall or ceiling compositions that may be found in an existing structure.
6. Complete statements about conditions for using optional calculations for additional loads to existing installations.
7. Arrange in order the steps for determining the number of conductors allowed in a conduit, based on conductors of the same size and type.
8. Arrange in order the steps for determining the number of conductors allowed in a conduit, based on conductors of different sizes or types.
9. Select true statements concerning replacement of receptacles in existing structures.
10. List permitted connections for equipment grounding conducgtors when replacing nongrounding-type receptacles with grounding-type receptacles and for branch-circuit extensions only in existing structures that do not have equipment-grounding conductors in the branch circuit.
11. Determine the number of conductors allowed to be added to an existing conduit. (Assignment Sheet 1)
12. Install a metallic box with dry-wall grips in a plasterboard wall. (Job Sheet 1)
13. Secure a box with dry-wall supports (box tins). (Job Sheet 2)
14. Install a plastic box with dry-wall grips in a plasterboard wall. (Job Sheet 3)

15. Install a box in a paneled wall. (Job Sheet 4)

16. Install a box in a concrete block wall. (Job Sheet 5)

17. Install a box in a brick wall. (Job Sheet 6)

18. Install a box in a ceiling with an accessible attic. (Job Sheet 7)

19. Install cable between an existing box and a newly installed box horizontally along a wall in a channel behind baseboard. (Job Sheet 8)

20. Install cable between an existing box and a newly installed box, using an underfloor crawl space. (Job Sheet 9)

21. Install cable between an existing box and a newly installed box, using attic space. (Job Sheet 10)

Information Sheet

Objective 1

Terms and definitions

a. **Brick bat**—Piece of brick

b. **Channel**—Groove formed in materials

c. **Cross sectional area**—Area in square inches allowed in a conduit or tubing; area for conductors in a conduit or tubing

d. **Drop chain**—Short length of small chain used to pull conductors or flexible conduit through an enclosed space or wall cavity

e. **Drop cloth**—Cloth used to catch falling debris from cutting or chipping work

f. **Fish**—Establishing a connection between two points so that a cable can be installed

g. **Fish wire**—Length of wire with a hook formed in one end to catch materials being fished in a space

h. **Lath and plaster**—Old method for covering interior walls; small strips of wood spaced evenly over studs to support and hold plaster

i. **Pipe chase**—Usually, a vertical space between two floors, dedicated for the running or pipes and conduits between floors

j. **Plasterboard (Sheetrock®)**—Flat sheet used in construction as a wall covering; it has an outer covering of felt sandwiching a gypsum plaster core

k. **Stud finder**—Compass-type tool that uses a magnet to find nails and thus indicate stud locations

l. **Underfloor crawl space**—Working space underneath the house

Objective 2

Construction members common in existing structures

Figure 1

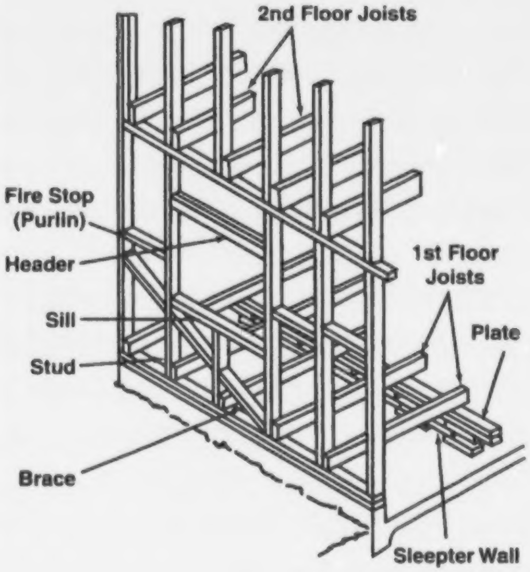
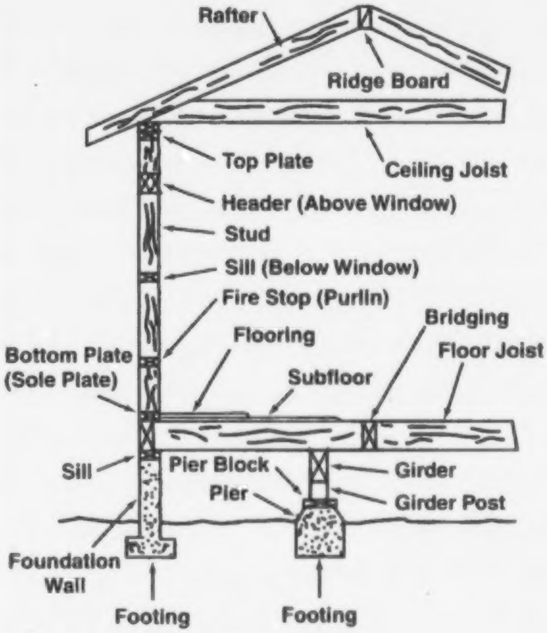

2nd Floor Joists
Fire Stop (Purlin)
Header
1st Floor Joists
Sill
Plate
Stud
Brace
Sleepter Wall

Figure 2


Rafter
Ridge Board
Top Plate
Ceiling Joist
Header (Above Window)
Stud
Sill (Below Window)
Fire Stop (Purlin)
Bridging
Flooring
Floor Joist
Bottom Plate (Sole Plate)
Subfloor
Sill
Pier Block
Girder
Pier
Girder Post
Foundation Wall
Footing
Footing

Objective 3

Common routes for new cable installations in existing structures

a. Vertically in a wall

b. Horizontally in a channel behind baseboard

c. Horizontally in underfloor crawl space

d. Horizontally in an attic

Figure 3

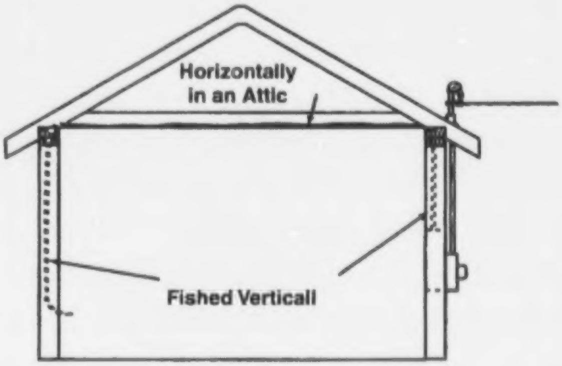
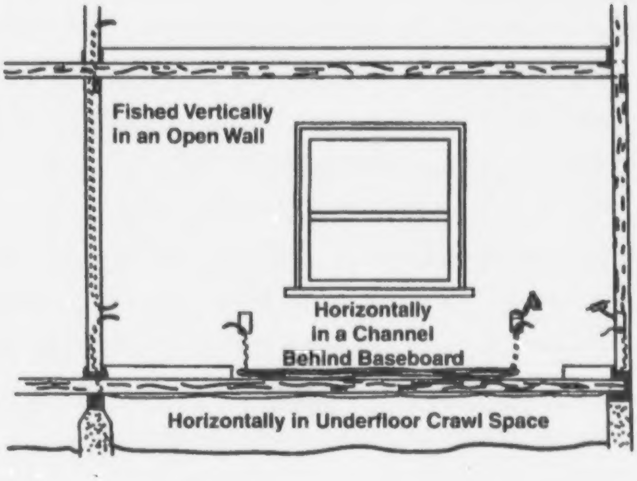

Horizontally
in an Attic
Fished Verticall

Figure 4


Fished Vertically
In an Open Wall
Horizontally
in a Channel
Behind Baseboard
Horizontally in Underfloor Crawl Space

Information Sheet

Objective 4

Possible methods for getting cable through or around construction members

Note: Good electricians can think their way around almost anything.

a. Top plates

- Straight drilling
- Angle drilling
- Lifting a shingle and drilling
- Over top plate and back through insulation board inside eave

  Note: To make a safe professional installation, select the method that is easiest and causes the least structural boring or changing.

b. Bottom plates (sole plate)

- Top drilling behind baseboard
- Bottom drilling

  Note: Bottom drilling is the preferred method because of the time involved in removal and reinstallation of baseboard.

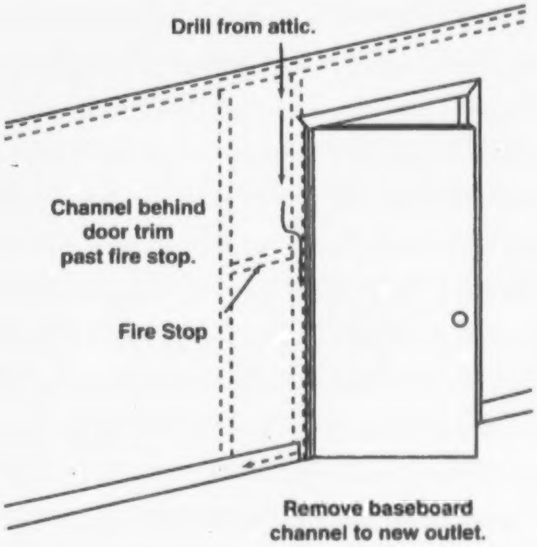
c. Fire stops

- Lifting shingle and top drilling through block with extension

  Note: This method works if the fire block is fairly high in the wall.

- Top drilling with door trim and baseboard removal (Figure 5)

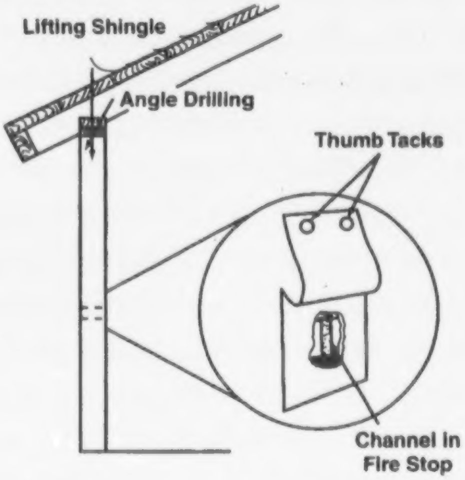
Figure 5


Drill from attic.
Channel behind door trim past fire stop.
Fire Stop
Remove baseboard channel to new outlet.

- Top drilling and channeling past (Figure 6)

  Note: Be sure to smooth out your work with spackling or joint compound before laying wallpaper back down.

  Figure 6


Lifting Shingle
Angle Drilling
Thumb Tacks
Channel In Fire Stop

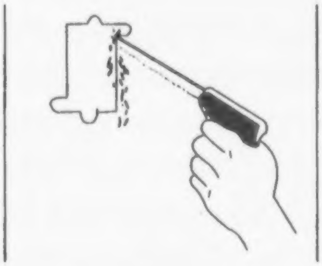
Objective 5

Wall or ceiling composition

a. Plasterboard

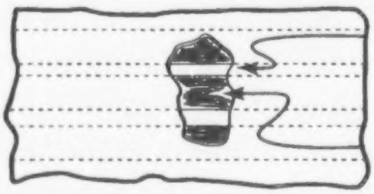
Note: This commonly called Sheetrock® and is used on the majority of interior walls in new structures.

Figure 7



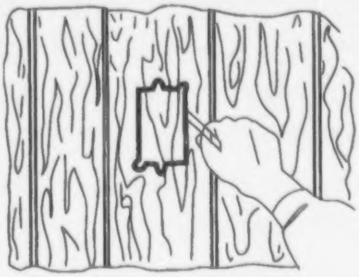
b. Lath and plaster

Figure 8



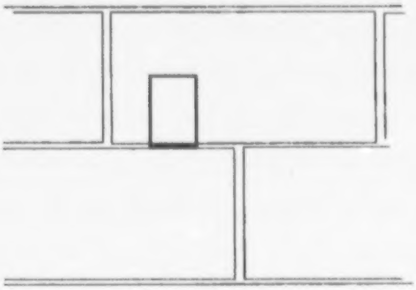
c. Paneling

Figure 9



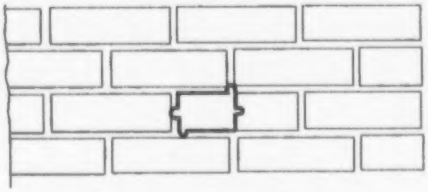
d. Concrete block

Figure 10



e. Brick

Figure 11



Objective 6

Optional calculation for additional loads to existing installations

Note: For the purpose of allowing additional loads to be connected to existing feeders and services, it should be permitted to use the actual maximum KVA demand figures to determine the existing load on a service or feeder when all the following conditions are met. Refer to *NEC* Article 220.35(1)(2)(3).

a. The maximum demand data is available in kVA for a minimum of a 1 year period.

b. The existing demand at 125 percent plus the new load does not exceed the ampacity of the feeder or rating of the service.

c. The feeder or service has overcurrent protection in accordance with sections 240.4, and the service has overload protection in accordance with 230.90.

Note: Article 230.90 requires overload protection in each ungrounded conductor. Article 240.4 requires that conductors other than flexible cords and fixture wires be protected against overcurrent in accordance with their ampacities as specified in Section 310.15.

Objective 7

Steps for determining the number of conductors allowed in a conduit, based on conductors of the same size and type.

a. Determine size of existing conduit.

b. Determine number and size of existing conductors.

c. Find the type of conduit in Appendix C, Tables C1–C12(A).

d. Find the conductor type and size listed under that type of conduit.

e. Determine number of conductors that may be added.

Example: An existing $1^1/2''$(41) flexible metal conduit contains two #1/0 THW-2 conductors. Two more #1/0 THW-2 conductors need to be added to feed a new circuit.

- Locate flexible metal conduit in Appendix C.
- Under the column titled "type," locate THW-2 where it corresponds to 1/0 in the column titled "conductor size."
- Read "3" at the intersection of #1/0 conductor and $1^1/2''$(41) conduit. This is the maximum allowable number of #1/0 conductors that may be placed in $1^1/2''$(41) flexible metal conduit.

  Since the maximum allowable number of conductors is 3, the two additional #1/0 conductors may not be placed within that run of conduit. Therefore, a new conduit must be run.

Objective 8

Steps for determine the number of conductors allowed in a conduit, based on using conductors of different sizes or types.

a. Determine size of existing conduit.

b. Determine number and size of existing conductors.

c. Find area of conduit or tubing, using Table 4, Chapter 9 of the *NEC*.

d. Compute total area occupied by existing conductors, based on Table 5, Chapter 9 of the *NEC*.

e. Determine number of conductors that may be added.

Example: An existing 1-inch intermediate metal conduit contains three #8 THHN conductors. Four #12 THW conductors need to be added to feed a new circuit.

1-inch(27) intermediate metal conduit with over two conductors has an area of .384 square inches (248 square millimeters) (Table 4, Chapter 9)

- #8 THHN has an area of .0366 sq. in. (Table 5, Chapter 9)

  $$\begin{array}{l} .0366 \text{ sq. in.} \\ \underline{\quad \times 3} \\ .1098 \text{ sq. in.} \end{array}$$

- #12 THW has an area of .0260 sq. in. (Table 5, Chapter 9)

  $$\begin{array}{l} .0181 \text{ sq. in.} \\ \underline{\quad \times 4} \\ .0724 \text{ sq. in.} \end{array}$$

  Total area required for conductors is:

  $$\begin{array}{r} .1098 \\ \underline{+.0724} \\ .1822 \text{ sq. in.} \end{array}$$

- .1822 is less than .384; therefore, the four #12 THW conductors may be added or

Objective 9

Replacement of receptacles in existing structures

Note: Replacement of receptacles shall comply with *NEC* Article 406.3(D)(1), (2), and (3) as applicable.

a. **Grounding-type receptacles**—If a means of grounding exists in the receptacle enclosure or a grounding conductor is properly installed, grounding-type receptacles must be used and connected to the grounding conductor.

b. **Ground-fault circuit-interrupters**—If required by *Code* at the replacement location, ground-fault circuit-interrupter protected receptacles shall replace other nongrounding type receptacles.

c. **Nongrounding-type receptacles**

- A nongrounding-type receptacle(s) may be replaced with another nongroundint-type receptacle(s).

- A ground-fault circuit-interrupter may replace a nongrounding-type receptacle but shall be marked with the words "No Equipment Ground".

  Note: An equipment-grounding conductor shall not be connected from the ground-fault circuit-interrupter receptable to any outlet supplied from the ground-fault circuit-interrupter receptacle.

- A nongrounding-type receptacle(s) may be replaced with a grounding-type receptacle(s) where supplied through a ground-fault circuit-interrupter but shall be marked with the words "GFCI Protected" and "No Equipment Ground".

  Note: An equipment grounding conductor shall not be connected between the grounding-type receptacles.

Objective 10

Equipment grounding connections in existing structures (*NEC* Art: 250.130(C))

a. For replacement of nongrounding-type receptacles with grounding-type receptacles and for branch-circuit extensions only in existing structures that do not have an equipment grounding conductor in the branch circuit, the equipment grounding conductor shall be permitted to be connected to any of the folowing:

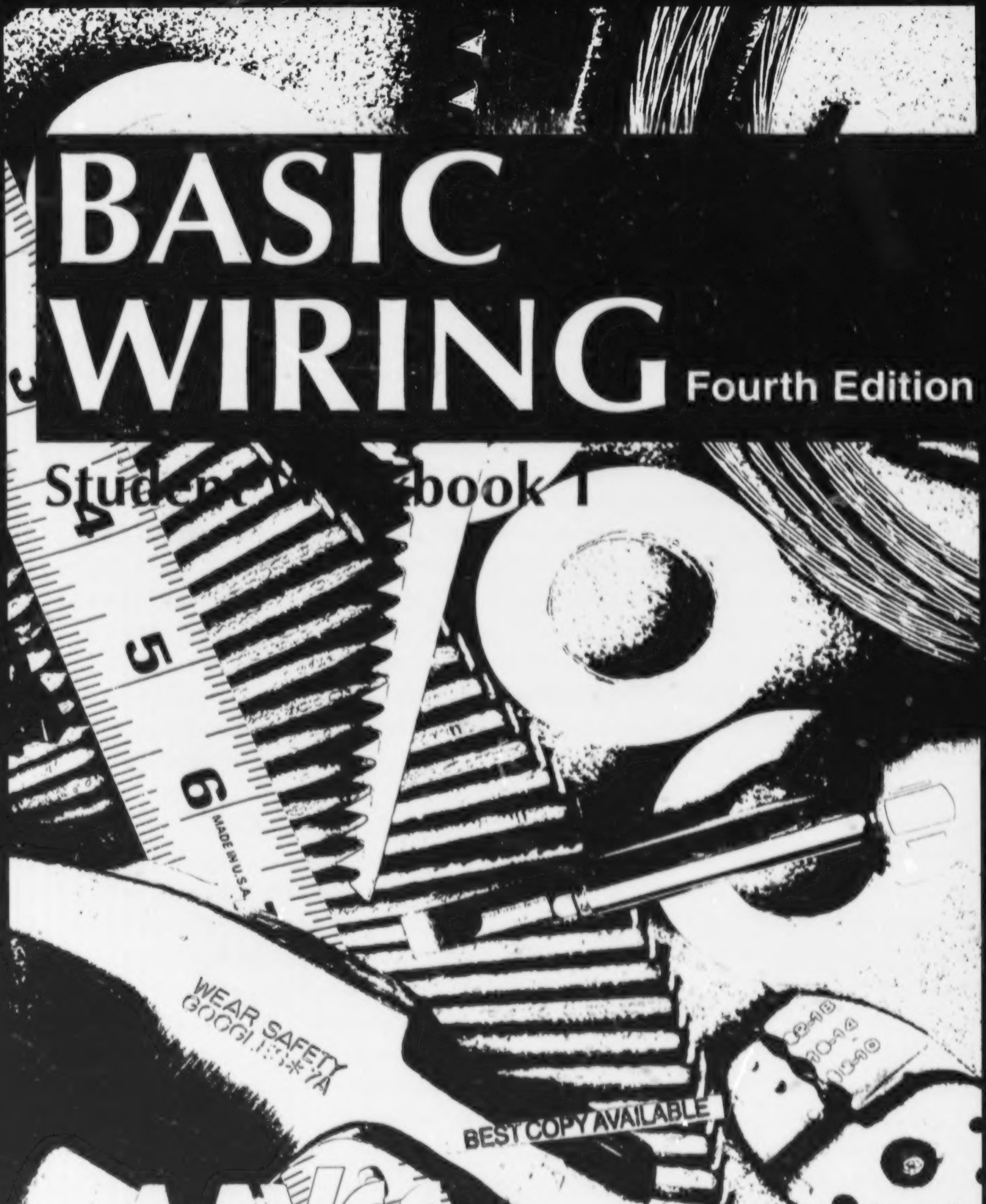
   - Any accessible point on the grounding electrode system. (see *NEC* Art: 250.50)
   - Any accessible point on the grounding electrode conductor.
   - The equipment grounding terminal bar within the enclosure where the branch circuit for the receptacle or branch circuit originates.
   - For grounded systems, the grounded service conductor within the service equipment enclosure.
   - For grounded systems, the grounding terminal bar within the service equipment enclosure.

   Note: The installation of grounding-type receptacles shall not be used as a requirement that all cord-and-plug connected equipment be of the grounded type. (NEC Art: 406.3(E))

BASIC WIRING

Fourth Edition

Student Workbook 1


3
4
5
6
MADE IN U.S.A.
WEAR SAFETY GOGGLES *7A
12-18
10-14
10-10
8-32
24
MAVCC

BEST COPY AVAILABLE

849

References 2002
National Electrical Code

02-015641 CN801342

Basic Wiring

Fourth Edition

Student Workbook 1

Units 1-9

Written by

Stan Kaltwasser
Gary Flowers
Don Blasingame

Revised by

Dan Ipock
Glenn Fleming

Project coordinated by

Glenn Fleming

Developed by

Multistate Academic and Vocational Curriculum Consortium, Inc.
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

©2002

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

801342

02-015641

©2002 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Printed in the United States of America by the
Oklahoma Department of Career and Technology Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Workbook Contents

Unit 1 **Occupational Introduction**

Focus Assignment

List Careers Associated with the Electrical Trade 1

Assignment Sheets

1—Interview an Electrical Worker 3
2—Compare Employment Opportunities in the Electrical Field 5

Unit 2 **General Safety and First Aid**

Focus Assignment

Locate Material Safety Data Sheets 7

Assignment Sheets

1—Interpret a Material Safety Data Sheet 9
2—Draw a Layout of Your School Shop and Apply the Safety Color *Code* 15
3—State Portable Fire Extinguisher Types, Symbols, and Operating Instructions 17
4—Identify and Correct Safety Violations 19

Job Sheets

1—Operate a Fire Extinguisher 21
2—Lift a Heavy Object Properly 23
3—Place and Climb a Ladder Safely 25

Unit 3 **Electrical Safety**

Focus Assignment

Read About Controlling Electrical Hazards 27

Assignment Sheets

1—Identify and Describe Safety Violations 35
2—Solve Problems Concerning Electrical Safety Practices 37

Workbook Contents

Unit 4

Related Math and Measuring

Assignment Sheets

1—Add Whole Numbers 39
2—Subtract Whole numbers 43
3—Multiply Whole Numbers 47
4—Divide Whole Numbers 51
5—Reduce Fractions to Lowest Terms 55
6—Convert Fractions and Mixed Numbers 57
7—Add Fractions 59
8—Subtract Fractions 63
9—Multiply Fractions 69
10—Add Decimal Numbers 71
11—Subtract Decimal Numbers 75
12—Multiply Decimal Numbers 79
13—Divide Decimal Numbers 83
14—Convert Fractions and Percentages 87
15—Solve Percentage Problems 91
16—Calculate Area of Geometric Figures 95

Unit 5

Hand Tools

Focus Assignment

List and Price Electrician's Tools 99

Assignment Sheet

1—Measure Objects Using a Tape Measure 101

Job Sheets

1—Clean and Lubricate an Adjustable Hand Tool 105
2—Use a Cutting/Crimping Tool 107
3—Adjust Wire Strippers 111
4—Set Up and Use a Hacksaw to Cut Conduit 113
5—Ream and Thread Rigid Conduit 115
6—Bend EMT Conduit 119
7—Use a Knockout Punch 123
8—Use a Hole Saw 127

Unit 6

Powered/Specialty Tools and Equipment

Assignment Sheet

1—Determine Dimensions on a Drawing Using an Architect's Scalep 129

Job Sheets

1—Use a Hydraulic Knockout Punch 133
2—Bend a 90-Degree Stub Using a Hydraulic Pipe Bender 137
3—Make Offset and 90-Degree Bends Using an Electric PVC Heater 139
4—Cut, Ream, and Thread Rigid Conduit with a Power Threader 145
5—Measure Resistance Using a VOM 149
6—Measure DC Voltages using a VOM 151
7—Measure AC Voltages using a VOM 153
8—Measure Amperage Using a Clamp-on Ammeter 157
9—Determine Current of a Multiple Loop Using a Clamp-on Ammeter 159
10—Check Conductor Insulation with a Megger 161

Unit 7

Using Trade Information

Focus Assignment

Using the *National Electrical Code* 163

Assignment Sheets

1—Use the *National Electrical Code* index to answer questions about *Code* sections 165
2—Use the *National Electrical Code* title page, table of contents, and introduction to answer questions 167
3—Use the *National Electrical Code* first chapter to define terms 169
4—Use the *National Electrical Code* to answer general questions related to residential wiring 173
5—Use the *National Electrical Code* to locate allowable ampacities for various conductors 175
6—Use the *National Electrical Code* to interpret conduit fill tables 177
7—Find information in the *National Electrical Code* 181

Workbook Contents

Unit 8 **Basic Equipment**

Assignment Sheet

1—Determine the Correct Number of Conductors for Boxfill 187

Job Sheets

1—Install Outlet Boxes on Wood Studs on a Framed Wall 191
2—Install Outlet Boxes on Steel Structures and Rods Using Caddy Clips 197
3—Install Outlet Boxes on Steel Studs Using Caddy Metal Clips for Switch Boxes 201
4—Install Masonry Boxes in a Block Wall Using Caddy Metal Clips for Switch Boxes 205

Unit 9 **Basic Theory**

Assignment Sheets

1—Draw a Diagram of the Power Distribution Supplying Your School Shop or Home 209
2—Solve Problems for Unknown Voltage 211
3—Solve Problems for Unknown Amperage 213
4—Solve Problems for Unknown Resistances and Wattages 215
5—Solve Problems for an Unknown Quantity 217

Objective 11

Focus Assignment—List Careers Associated with the Electrical Trade

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Listed occupations	______
• Prepared for discussion	______

Basic Skills

Employability

Directions

Make a list of all occupations and areas of industry you think electrical workers could be involved with. Be prepared to discuss your list in class.

Objective 12

Assignment Sheet 1—Interview an Electrical Worker

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Interview set up and process	______
• Four of four Assignment Sheet 1 questions answered	______
• Preparation for class discussion	______

Basic Skills

Writing · Oral Communication · Interpersonal · Employability

Introduction

Knowing more about what electricians do, what type of training is required, and the outlook for the occupation, will help you make better decisions about your future and this course.

Directions

Locate and interview an electrical worker in your area. Answer the following questions based on your interview. Be prepared to discuss the interview in class.

a. What is the occupation of the worker being interviewed, and what are the job responsibilities?

b. What type of training is needed?

____

____

____

____

____

____

____

____

c. What kind of salary can be expected?

____

____

____

____

____

____

____

d. What is the future outlook for this occupation?

____

____

____

____

____

____

____

Objective 13

Assignment Sheet 2—Compare Employment Opportunities in the Electrical Field

Name ____________________ Overall Rating ________

Date ____________________

Evaluation Criteria	Rating
• Appropriateness of advertisements collected	____
• Neatness, appearance, and grammatical correctness of paragraph	____
• Preparation for class discussion	____

Basic Skills

Reading Writing Employability

Directions

Collect four classified advertisements from your local or area newspaper relating to employment opportunities in the electrical field. Compare each opportunity and determine which one would best suit your interests and needs. Write a paragraph on why you chose that occupation. Be prepared to discuss your paragraph in class.

Assignment Sheet 2

Objective 31

Focus Assignment—Locate Material Safety Data Sheets (MSDS)

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Located several MSDS's	______
• Identified differences	______
• Listed differences	______

Basic Skills

Reading Interpersonal

Directions

Locate several MSDS's within your shop. Next locate several MSDS's within other shops at your location, then team up with a partner and list the differences between the forms and the types of information listed on each MSDS.

Be prepared to discuss the differences in class.

Objective 32

Assignment Sheet 1—Interpret a Material Safety Data Sheet

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	Rating
• Directions followed	______
• All answers correct per Answers to Assignment Sheet 1	______

Basic Skills

Reading Writing

Directions

Review the material in Objective 14 of the information sheet, and locate and study the information presented in Student Supplement 2, "Guidelines for Interpreting Material Safety Data Sheets."

Use the MSDS at the end of this assignment sheet to answer the following questions. Write your answers on the blanks provided below each item.

MSDS Gel Graffiti®

a. What is this product used for?

____

b. What is the main ingredient in this product?

____

c. What does this product look like?

____

d. What percentage of this product is volatile (capable of exploding)?

____

e. What extinguishing agents should be used on fires created by this product?

____

f. What may happen is aerosol containers of this product are exposed to temperatures higher than 130°F?

____

g. What is the TLV for this product?

____

h. Are any of the ingredients in this product suspected of causing cancer? Explain.

____

____

____

i. What is the primary way in which this product enters the body?

____

j. What are the symptoms of overexposure to this product?

____

____

____

k. What first-aid measure should **not** be taken if this product is ingested?

____

l. What conditions should you avoid using with this product?

____

____

m. What products should you avoid using with this product?

____

____

n. How should you dispose of this product?

____

____

____

o. What special protective measures should you take when using this product?

____

____

____

p. What special hygiene precautions should you take when using this product?

____

____

Assignment Sheet 1

JCLE035
CLEANER, GRAFFITI GEL
3-15-89

01/003/0020

HAZARDOUS COMMUNICATION GUIDE

Material Safety Data Sheet

N/A = Not Applicable
N/D = No Data
N/E = Not Established

Supersedes: *10/20/95*

I. General Information

Data Revised: *12/9/88*

Chemical Name & Synonyms
N/A

Chemical Family
Engine degreaser (gelled)

Proper DOT Shipping Name
Consumer commodity 48580 Sub 3

Manufacturer
Crain Chemical Co., Inc.

Manufacturer's Address
P.O. Box 540995, Dallas, TX 75354

Trade Name & Synonyms
GEL GRAFFITI

Formula
N/A

DOT Hazard Classification
ORM-D

Manufacturer's Phone Number
214/358-3301

Chemtrec Phone Number
1-800-424-9300

II. Ingredients

Principal Hazardous Components	Percent	Threshold Limit Value (units)	
		OSHA	ACGIH
Ethanol *CAS# 64-17-5*	*N/A*	*1000 ppm*	*1000 ppm*
Aromatic Hydrocarbon *CAS# 64742-06-9*	*N/A*	*100 ppm*	*100 ppm*
Chlorinated Hydrocarbon *CAS# 75-09-2*	*N/A*	*500 ppm*	*500 ppm*
Glycol Ethers *CAS# 111-76-2*	*NA*	*50 ppm*	*25 ppm*

III. Physical Data

Boiling Point (°F)
N/A

Vapor Pressure (mm Hg.)
N/D

Vapor Density (Air = 1)
N/E

Solubility in Water
N/A

Appearance & Odor
Opaque, white gel/characteristic odor

Specific Gravity (H_2O = l)
N/A

Percent Volatile By Volume (%)
77

Evaporation Rate (____ = 1)
N/A

pH
N/A

IV. Fire and Explosion Hazard Data

Flash Point (Test Method)
Flame projection 18" plus

Flammable Limits
Flammable

Extinguishing Media
CO_2*, Foam*

Special Fire Fighting Procedures
Self-contained breathing apparatus

Auto Ignition Temperature
N/E

LEL
N/E

UEL
N/E

Unusual Fire & Explosion Hazards
Do not expose aerosols to temperatures above 130°F or the container may rupture.

JCLE035 *01/003/0020*
CLEANER, GRAFFITI GEL
3-15-89

HAZARDOUS COMMUNICATION GUIDE

V. Health Hazard Data

Threshold Limit Value
50 ppm

OSHA Threshold Limit Value
See Section II

ACGIH Threshold Limit Value
See Section II

Carcinogen - NTP Program
Chlorinated hydrocarbon (animal data only)

Carcinogen - IARC Program
Same as (NTP)

Symptoms of Exposure
Headaches, dizziness, irritation, burning (eyes), nausea, asphyxia and possible chemical pneumonitis if aspirated into lungs.

Medical Conditions Aggravated by Exposure
May aggravate existing eye, skin, or upper respiratory conditions.

Primary Route(s) of Entry
Inhalation

Emergency First Aid
Eyes: Flush with water for 15 minutes. If irritated, see physician. Skin: Wash with soap and water. If irritated, see physician. Inhalation: Move to fresh air. Resuscitate if necessary. Get medical aid. Ingestion: Do NOT induce vomiting. Call physician immediately.

VI. Reactivity Data

Stability		Unstable
	X	Stable
Incompatibility		
Hazardous Polymerization		May Occur
	X	Will Not Occur

Conditions to Avoid
Heat, sparks, welding arcs, open flames

Materials to Avoid
Strong oxidizing agents

Conditions to Avoid
None known

Hazardous Decomposition Products
CO_2, CO, HCL, Small amounts of phosgene and chlorine

VII. Environmental Protection Procedures

Spill Response
Absorb with suitable medium. Incinerate or land fill according to local, state, or federal regulations. Do not flush to sewer.

Waste Disposal Method
Aerosol cans, when vented to atmospheric pressure through normal use, pose no disposal hazards.

VIII. Special Protection Information

Eye Protection
Safety glasses recommended

Respiratory Protection (Specific Type)
If vapor conc. exceeds TLV, use respirator approved by U.S. Bureau of Mines for organic vapor.

Other Protection
None

Skin Protection
Neoprene gloves recommended

Ventilation Recommended
Adequate ventilation to keep vapor concentration below TLV.

JCLE035
CLEANER, GRAFFITI GEL
3-15-89

01/003/0020

HAZARDOUS COMMUNICATION GUIDE

IX. Special Precautions

Hygienic Practices in Handling & Storage

Wash with soap and water before handling food. Do not puncture or incinerate containers. Do not store at temperatures above 130°F.

Precautions For Repair & Maintenance of Contaminated Equipment

Remove all ignition sources i.e., heat, sparks, open flames, etc.

Other Precautions

Avoid food containers. Keep out of reach of children. Remove ignition sources. Avoid breathing vapors.

Objective 33

Assignment Sheet 2—Draw a Layout of Your School Shop and Apply the Safety Color Code

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Included all required items	______
• All items correctly color-coded	______
• Layout neat and legible	______

Basic Skills

Reading Writing Critical Thinking

Directions

Review the material in Objective 16 of the information sheet.

Draw a layout of your school shop including all machines, workbenches, tools, first aid kits, and fire prevention equipment. Us the federal safety color code to identify equipment, hazards, safety features, and exposed parts that could cause accidents.

Objective 34

Assignment Sheet 3—State Portable Fire-Extinguisher Types, Symbols, and Operating Instructions

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Directions followed	______
• All answers correct per Answers to Assignment Sheet 3	______

Basic Skills

Reading Critical Thinking

Introduction

When a fire occurs, it is very important not only to be able to size-up and identify the type of fire, but also to choose an extinguisher that will be effective in putting out the fire.

Directions

Review the material presented in Objectives 18, 19, and 20 of the information sheet, and locate and study the information presented in Student Supplement 3.

Next, read and follow the directions with each item below.

a. Match extinguisher picture symbols on the following page with the extinguisher's intended applications. Write the correct letters on the blanks.

_____1. Class A and B fires but not Class C fires

_____2. Flammable liquids

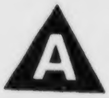
_____3. Class B and C fires but not Class A fires

_____4. Ordinary combustibles

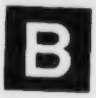
_____5. Class A fires but not Class B and C fires

_____6. Electrical equipment

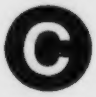
a.



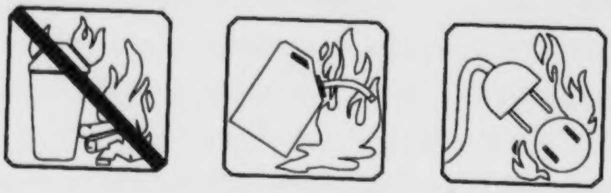
b.



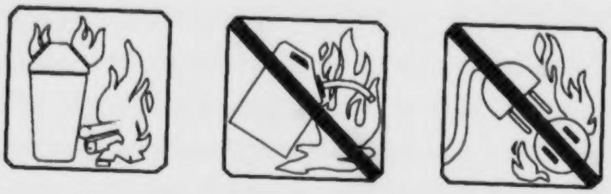
c.



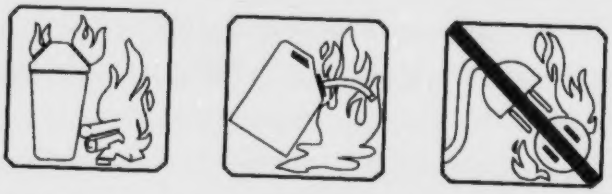
d.



e.



f.



b. Match types of extinguishers with the Class(es) of fires they are intended to extinguish.

1. Foam
2. Pump Tank
3. Carbon Dioxide
4. Halon
5. Dry Chemical

_____ a. Class "A" fires only

_____ b. Class "B" or "C" fires only

_____ c. Class "A" or "B" fires only

_____ d. Class "C" fires only

_____ e. Class "B" or "C" fires only

c. Complete fire-extinguisher general operating instructions that follow the letters P-A-S-S.

1. **P** ______________________________

2. **A** ______________________________

3. **S** ______________________________

4. **S** ______________________________

Objective 35

Assignment Sheet 4—Identify and Correct Safety Violations

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Five of six safety violations identified	______
• Five of six corrective measures described	______

Basic Skills

Reading Writing Critical Thinking

Directions

The following scenario relates unsafe acts that may be found in the classroom. List the safety violations and corrective measures that should have been taken to prevent them.

Scenario

The morning class was loading materials and equipment for their school project house. John, one of the students, went to the tool room and got the 1/2-inch drill motor that had a red tag attached to the power cord. John noticed there was a stripped wire on the drill, but he did not think it was that bad. John pulled the red tag off the drill and threw it in the trash. Then John went to the tape cabinet to find some electrical tape. The bell rang, so John placed the drill with the other tools and went to catch the bus.

When the afternoon class arrived, they finished loading the tools and materials onto the bus and went to the project house. Jim was assigned to drill out the house. He picked up the drill that John had left with the other tools, and started to drill. The plumbing students were also working in the house testing water lines, and the floor was covered with water. While drilling in the bathroom, Jim pulled the drill cord through the water and received a severe electrical shock.

a. List the safety violations.

____

____

____

____

b. List the corrective measures that should have been taken.

Objective 36

Job Sheet 1—Operate a Fire Extinguisher

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Extinguisher was carried properly	_____
• User was within stream reach of fire	_____
• P-A-S-S sequence was followed	_____
• Fire was completely extinguished	_____

Basic Skills

Reading Employability

Introduction

Using a portable fire extinguisher properly requires more than simple manipulation. You must always size up the fire and decide whether it can be extinguished with an extinguisher. If the fire is too large or too smoky, call the fire department. If the fire is small enough to be extinguished with an extinguisher, always fight it with your back to a means of escape.

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and, Materials

- Portable fire extinguisher suitable for a Class A fire
- Small Class A fire in clear, safe area
- Charged hose (hose hooked up to a water source and with water in the hose) or another secondary means of extinguishment for backup

Procedure

Caution: This procedure should only be performed outdoors on a windless day, and only under the direct supervision of your instructor.

☐ 1. Pick up the fire extinguisher by its handle.

Note: *All* modern fire extinguishers are designed to be used in an *upright* position.

☐ 2. Read the fire extinguisher label to determine proper stream reach.

Note: *Stream reach* is the distance the extinguishing agent is propelled. Stream reach varies with extinguisher, and may range from 3 to over 20 feet. Normally, the smaller the extinguisher, the shorter the stream reach.

☐ 3. Walk—do not run—to within stream reach of the fire.

☐ 4. **Pull** the pin at the top of the extinguisher that keeps the handle from being pressed.

Note: Pulling the pin automatically breaks the plastic or thin wire inspection band.

☐ 5. **Aim** the nozzle toward the fire, first releasing it from its clip if applicable.

☐ 6. **Squeeze** the discharge handle (above the carrying handle) to release the extinguishing agent.

☐ 7. **Sweep** the nozzle back and forth at the base of the flames.

☐ 8. After the fire appears to be out, probe for remaining hot spots.

☐ 9. Make sure the fire is out by extinguishing any hot spots.

Evaluator's comments: ____________________

____

____

Objective 37

Job Sheet 2—Lift a Heavy Object Properly

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Load was safely lifted	____
• Load was safely carried and set down	____

Basic Skills

Reading Employability

Introduction

The number-one worker injury in America today is back strain or injury. Most of these injuries come from trying to lift an object that is too heavy or from lifting an object improperly. It is very important, therefore, that you learn to assess the weight of a load to be lifted, and either get help to lift the load or lift the load properly, using your leg muscles, not your back.

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and, Materials

- Large, heavy box
- Gloves
- Lower-back support belt

Procedure

☐ 1. Put on gloves and lower-back support belt.

☐ 2. Size up the load.

☐ 3. Place your feet close to the object and 8 to 12 inches apart for good balance.

☐ 4. Bend your knees to a degree that is comfortable.

☐ 5. Grip the box firmly with both hands.

☐ 6. Keeping your back straight and using your leg muscles, lift the box to waist height and hold close to your body.

Caution: Do not make any turning or twisting motions until the lift is complete.

☐ 7. Turn by changing foot position, making sure that your path is clear.

☐ 8. Carry the box to the new location, using a normal walking gait and keeping your view unobstructed.

☐ 9. Reverse the lifting procedure to set the box down, taking care to bend your knees, keep your back straight, and avoid setting the box on your fingers or feet.

Evaluator's comments: ______________________________

____

____

Objective 38

Job Sheet 3—Place and Climb a Ladder Safely

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Ladder was picked up correctly and safely	____
• Ladder was carried correctly and safely	____
• Ladder was placed correctly and safely (1 foot from wall for every 4 feet of ladder height; at least three rungs above work)	____
• Ladder was climbed and descended safely	____

Basic Skills

Reading Employability

Introduction

To avoid falls and strains, correct and thoughtful placement of a ladder is very important. The ladder should be lifted correctly, and placed so that its base is at least a foot from the wall for each 4 feet of height. The ladder should also be placed close enough to the work so that the user does not need to stretch to reach the work.

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and, Materials

- One 12-foot straight ladder
- Class member to hold ladder

Procedure

☐ 1. Kneel beside the ladder, facing its top at about midpoint, knee closest to ladder on the ground.

☐ 2. Reach across the ladder and grasp the rung opposite close to the far siderail.

☐ 3. Stand up—using your legs, not your back.

☐ 4. As you stand, pivot toward the other end of the ladder, slip your free arm between convenient rungs, and lift the ladder so that its top beam rests on your shoulder.

☐ 5. Carry the ladder to the work area, taking care to avoid bumping it into anything or anyone.

- ☐ 6. Check the work area for overhead electrical obstructions.
- ☐ 7. Slip the ladder from your shoulder, and rest it against the wall.
- ☐ 8. Adjust the ladder placement.
  - ☐ a. Shoes are secure on flat surface.
  - ☐ b. Base is approximately 1 foot from the wall for each 4 feet of working ladder height.
  - ☐ c. Top of ladder is at least three rungs above the work.
- ☐ 9. Ask a classmate to heel the ladder.
- 10. Climb the ladder to the work.
  - ☐ a. Facing the ladder.
  - ☐ b. Hands on rungs or siderails, and.
  - ☐ c. Feet squarely on rungs.
- 11. Descend the ladder.
  - ☐ a. Facing the ladder.
  - ☐ b. Hands on rungs or siderails, and.
  - ☐ c. Feet squarely on rungs.

Evaluator's comments: ____________________

____

____

Objective 12

Focus Assignment—Read About Controlling Electrical Hazards

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Assignment answers complete	______

Basic Skills

Reading Writing

Directions

Read the following article entitled "Controlling Electrical Hazards."

This article provides an overview of basic electrical safety for individuals with little or limited training or familiarity with electrical hazards. The concepts and principles presented will help further an understanding of OSHA's electrical safety standards for general industry, Title 29 Code of Federal Regulations (CFR), Part 1910.302, Sub-part S-Design Safety Standards for Electrical Systems, and 1910.331 Electrical Safety-Related Work Practices Standard (1990).

In general, OSHA'S electrical standards are based on the National Fire Protection Associations' Standard NFPA 70E, Electrical Safety Requirements for Employee Workplaces, and in turn, from the *National Electrical Code* (*NEC*).

OSHA's electrical standards address concerns that electricity has long been recognized as a serious workplace hazard, exposing employees to such dangers as electric shock, electrocution, burns, fires, and explosions. In 1992, for example, the Bureau of Labor Statistics reported that 6,210 work-related deaths occurred in private sector workplaces employing 11 workers or more. Six percent of the fatalities, or around 347 deaths, were the direct result of electrocutions at work. What makes these statistics more tragic is that, for the most part, these fatalities could have been easily avoided.

OSHA'S electrical standards help minimize these potential hazards by specifying safety aspects in the design and use of electrical equipment and systems. The standards cover only those parts of any electrical system that an employee would normally use or contact. For example, the exposed and/or operating elements of an electrical installation-lighting, equipment, motors, machines, appliances, switches, controls, and enclosures-must be constructed and installed so as to minimize workplace electrical dangers.

For employers and employees in the 25 states operating OSHA'S approved workplace safety and health plans, their states may be enforcing standards and other procedures that while "at least effective" federal standards are not always identical to federal requirements.

How electricity acts?

Electricity is essential to modem life, both at home and on the job. Some employees work with electricity directly, as is the case with engineers, electricians, electronic technicians, and power line workers. Others, such as office workers and sales-people, work with it indirectly. As a source of power, electricity is accepted without much thought to the hazards encountered. Perhaps because it has become such a familiar part of our surroundings, it often is not treated with the respect it deserves.

To handle electricity safely, it is necessary to understand how it acts, how it can be directed, what hazards it presents, and how these hazards can be controlled. Operating an electric switch may be considered analogous to turning on a water faucet. Behind the faucet or switch there must be a source of water or electricity, with something to transport it, and with pressure to make it flow. In the case of water, the source is a reservoir or pumping station; the transportation is through pipes; and the force to make it flow is pressure, provided by a pump. For electricity, the source is the power generating station; current travels through electric conductors in the form of wires; and pressure, measured in volts, is provided by a generator.

Resistance to the flow of electricity is measured in ohms and varies widely. It is determined by three factors: the nature of the substance itself, the length and cross-sectional area (size) of the substance, and the temperature of the substance.

Some substances, such as metals, offer very little resistance to the flow of electric current and are called conductors. Other substances, such as bakelite, porcelain, pottery, and dry wood, offer such a high resistance that they can be used to prevent the flow of electric current and are called insulators.

Dry wood has a high resistance, but when saturated with water its resistance drops to the point where it will readily conduct electricity. The same thing is true of human skin.

When it is dry, skin has a fairly high resistance to electric current; but when it is moist, there is a radical drop in resistance. Pure water is a poor conductor, but small amounts of impurities, such as salt and acid (both of which are contained in perspiration), make it a ready conductor. When water is present either in the environment or on the skin, anyone working with electricity should exercise even more caution than they normally would.

How Shocks Occur?

Electricity travels in closed circuits, and its normal route is through a conductor. Electric shock occurs when the body becomes a part of the electric circuit. The current must enter the body at one point and leave at another. Electric shock normally occurs in one of three ways. Individuals-while in contact with the ground-must come in contact with both wires of the electric circuit, one wire of an energized circuit and the ground, or a metallic part that has become "hot" by contact with an energized conductor.

The metal parts of electric tools and machines may become energized if there is a break in the insulation of the tool or machine wiring. The worker using these tools and machines is made less vulnerable to electric shock when there is a low-resistance path from the metallic case of the tool or machine to the ground. This is done through the use of an equipment grounding conductor- a low-resistance wire that causes the unwanted current to pass directly to the ground, thereby greatly reducing the amount of current passing through the body of the person in contact with the tool or machine. If the equipment grounding conductor has been properly installed, it has a low resistance to ground, and the worker is protected.

Severity of the Shock?

The severity of the shock received when a person becomes a part of an electric circuit is affected by three primary factors: the amount of current flowing through the body (measured in amperes), the path of the current through the body, and the length of time the body is in the circuit. Other factors that may affect the severity of shock are the frequency of the current, the phase of the heart cycle when shock occurs, and the general health of the person.

The effects of electric shock depend upon the type of circuit, its voltage, resistance, current, pathway through the body, and duration of the contact. Effects can range from a barely perceptible tingle to immediate cardiac arrest.

A difference of less than 100 milliamperes exists between a current that is barely perceptible and one that can kill. Muscular contraction caused by stimulation may not allow the victim to free himself or herself from the circuit, and the increased duration of exposure increases the dangers to the shock victim. For example, a current of 100 milliamperes for 3 seconds is equivalent to a current of 900 milliamperes applied for .03 seconds in causing ventricular fibrillation. The so-called low voltages can be extremely dangerous because, all other factors being equal, the degree of injury is proportional to the length of time the body is in the circuit. LOW VOLTAGE DOES NOT IMPLY LOW HAZARD!

A severe shock can cause considerably more damage to the body than is visible. For example, a person may suffer internal hemorrhages and destruction of tissues, nerves, and muscles. In addition, shock is often only the beginning in a chain of events. The final injury may well be from a fall, cuts, burns, or broken bones.

Burns and Other Injuries

The most common shock-related injury is a burn. Burns suffered in electrical accidents may be of three types: electrical burns, arc burns, and thermal contact burns.

Electrical burns are the result of the electric current flowing through tissues or bone. Tissue damage is caused by the heat generated by the current flow through the body. Electrical burns are one of the most serious injuries you can receive and should be given immediate attention.

Arc or flash burns, on the other hand, are the result of high temperatures near the body and are produced by an electric arc or explosion. They should also be attended to promptly.

Finally, thermal contact burns are those normally experienced when the skin comes in contact with hot surfaces of overheated electric conductors, conduits, or other energized equipment. Additionally, clothing may be ignited in an electrical accident and a thermal burn will result. All three types of burns may be produced simultaneously.

Electric shock can also cause injuries of an indirect or secondary nature in which involuntary muscle reaction from the electric shock can cause bruises, bone fractures, and even death resulting from collisions or falls. In some cases, injuries caused by electric shock can be a contributory cause of delayed fatalities.

In addition to shock and burn hazards, electricity poses other dangers. For example, when a short circuit occurs, hazards are created from the resulting arcs. If high current is involved, these arcs can cause injury or start a fire. Extremely high-energy arcs can damage equipment, causing fragmented metal to fly in all directions. Even low-energy arcs can cause violent explosions in atmospheres that contain flammable gases, vapors, or combustible dusts.

Preventing Electrical Hazards

Electrical accidents appear to be caused by a combination of three possible factors- unsafe equipment and/or installation, workplaces made unsafe by the environment, and unsafe work practices. There are various ways of protecting people from the hazards caused by electricity. These include: insulation, guarding, grounding, electrical protective devices, and safe work practices.

Insulation

One way to safeguard individuals from electrically energized wires and parts is through insulation. An insulator is any material with high resistance to electric current.

Insulators-such as glass, mica, rubber, and plastic-are put on conductors to prevent shock, fires, and short circuits. Before employees prepare to work with electric equipment, it is always a good idea for them to check the insulation before making a connection to a power source to be sure there are no exposed wires. The insulation of flexible cords, such as extension cords, is particularly vulnerable to damage.

The insulation that covers conductors is regulated by Subpart S of *29 Code of Federal Regulations (CFR)* Part 1910.302, *Design Safety Standards for Electrical Systems*, as published in the *Federal Register* on January 16, 1981.

Subpart S generally requires that circuit conductors (the material through which current flows) be insulated to prevent people from coming into accidental contact with the current. Also, the insulation should be suitable for the voltage and existing conditions, such as temperature, moisture, oil, gasoline, or corrosive fumes. All these factors must be evaluated before the proper choice of insulation can be made.

Conductors and cables are marked by the manufacturer to show the maximum voltage and American Wire Gage size, the type letter of the insulation, and the manufacturer's name or trademark. Insulation is often color coded. In general, insulated wires used as equipment grounding conductors are either continuous green or green with yellow stripes. The grounded conductors that complete a circuit are generally covered with continuous white or natural gray-colored insulation. The ungrounded conductors, or "hot wires," may be any color other than green, white, or gray. They are often colored black or red.

Guarding

Live parts of electric equipment operating at 50 volts or more must be guarded against accidental contact. Guarding of live parts may be accomplished by:

- location in a room, vault, or similar enclosure accessible only to qualified persons;
- use of permanent, substantial partitions or screens to exclude unqualified persons;
- location on a suitable balcony, gallery, or platform elevated and arranged to exclude unqualified persons; or
- elevation of 8 feet (2.44 meters) or more above the floor.

Entrances to rooms and other guarded locations containing exposed live parts must be marked with conspicuous warning signs forbidding unqualified persons to enter.

Indoor electric wiring more than 600 volts and that is open to unqualified persons must be made with metal-enclosed equipment or enclosed in a vault or area controlled by a lock. In addition, equipment must be marked with appropriate caution signs.

Grounding

Grounding is another method of protecting employees from electric shock; however, it is normally a secondary protective measure. The "ground" refers to a conductive body, usually the earth, and means a conductive connection, whether intentional or accidental, by which an electric circuit or equipment is connected to earth or the ground plane. By "grounding" a tool or electrical system, a low-resistance path to the earth is intentionally created. When properly done, this path offers sufficiently low resistance and has sufficient current carrying capacity to prevent the buildup of voltages that may result in a personnel hazard. This does not guarantee that no one will receive a shock, be injured, or be killed. It will, however, substantially reduce the possibility of such accidents - especially when used in combination with other safety measures.

There are two kinds of grounds required by Design Safety Standards for Electrical Systems (Subpart S). One of these is called the "service or system ground." In this instance, one wire-called "the neutral conductor" or "grounded conductor" - is grounded. In an ordinary low-voltage circuit, the white (or gray) wire is grounded at the generator or transformer and again at the service entrance of the building. This type of ground is primarily designed to protect machines, tools, and insulation against damage.

To offer enhanced protection to the workers themselves, an additional ground, called the "equipment ground," must be furnished by providing another path from the tool or machine through which the current can flow to the ground. This additional ground safeguards the electric equipment operator in the event that a malfunction causes the metal frame of the tool to become accidentally energized. The resulting heavy surge of current will then activate the circuit protection devices and open the circuit.

Circuit Protection Devices

Circuit protection devices are designed to automatically limit or shut off the flow of electricity in the event of a ground-fault, overload, or short circuit in the wiring system. Fuses, circuit breakers, and ground-fault circuit interrupters are three well-known examples of such devices.

Fuses and circuit-breakers are over-current devices that are placed in circuits to monitor the amount of current that the circuit will carry. They automatically open or break the circuit when the amount of current flow becomes excessive and therefore unsafe. Fuses are designed to melt when too much current flows through them. Circuit breakers, on the other hand, are designed to trip open the circuit by electro-mechanical means.

Fuses and circuit breakers are intended primarily for the protection of conductors and equipment. They prevent over-heating of wires and components that might otherwise create hazards for operators. They also open the circuit under certain hazardous ground-fault conditions.

The ground-fault circuit interrupter, or GFCI, is designed to shutoff electric power within as little as 1/40 of a second. It works by comparing the amount of current going to electric equipment against the amount of current returning from the equipment along the circuit conductors. If the current difference exceeds 6 milliamperes, the GFCI interrupts the current quickly enough to prevent electrocution. The GFCI is used in high-risk areas such as wet locations and construction sites.

Safe Work Practices

Employees and others working with electric equipment need to use safe work practices. These include: deenergizing electric equipment before inspecting or making repairs, using electric tools that are in good repair, using good judgment when working near energized lines, and using appropriate protective equipment. Electrical safety-related work practice requirements are contained in Subpart S of 29 CFR Part 1910, in Sections 1910.331-1910.335.

Overhead Lines

If work is to be performed near overhead power lines, the lines must be deenergized and grounded by the owner or operator of the lines, or other protective measures must be provided before work is started. Protective measures (such as guarding or insulating the lines) must be designed to prevent employees from contacting the lines.

Unqualified employees and mechanical equipment must stay at least 10 feet (3.05 meters) away from overhead power lines. If the voltage is more than 50,000 volts, the clearance must be increased by 4 inches (10 centimeters) for each additional 10,000 volts.

When mechanical equipment is being operated near over-head lines, employees standing on the ground may not contact the equipment unless it is located so that the required clearance cannot be violated even at the maximum reach of the equipment.

Protective Equipment. Employees whose occupations require them to work directly with electricity must use the personal protective equipment required for the jobs they perform. This equipment may consist of rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets.

Tools. To maximize his or her own safety, an employee should always use tools that work properly. Tools must be inspected before use, and those found questionable, removed from service and properly tagged. Tools and other equipment should be regularly maintained. Inadequate maintenance can cause equipment to deteriorate, resulting in an unsafe condition.

Tools that are used by employees to handle energized conductors must be designed and constructed to withstand the voltages and stresses to which they are exposed.

Good Judgment. Perhaps the single most successful defense against electrical accidents is the continuous exercising of good judgment or common sense. All employees should be thoroughly familiar with the safety procedures for their particular jobs. When work is performed on electrical equipment, for example, some basic procedures are:

1. Have the equipment deenergized.
2. Ensure that the equipment remains deenergized by using some type of lockout and tag procedure.
3. Use insulating protective equipment.
4. Keep a safe distance from energized parts.

Directions

Answer the following questions and be prepared to discuss your answers in class.

a. List three factors that determine resistance to the flow of electricity.

1. ______________________________
2. ______________________________
3. ______________________________

b. Dry skin has a fairly ______________ resistance to electric current.

c. List the three primary factors that affect severity of shock when a person becomes part of an electric circuit.

1. ______________________________
2. ______________________________
3. ______________________________

d. What are the three types of electrical burns?

1. ______________________________

2. ______________________________

3. ______________________________

e. ________________ burns are normally experienced when the skin comes in contact with hot surfaces of overheated electrical conductors, conduits, or other energized equipment.

f. Ungrounded conductors, or "hot wires," may be any color other than

________, ________, or ________.

g. By "grounding" a tool or electrical system, a ________ - ________ path to the earth is intentionally created.

h. List three examples of circuit protection devices.

1. ______________________________

2. ______________________________

3. ______________________________

i. A GFCI works by comparing the amount of current going to electric equipment against the amount of current returning from the equipment. If the current difference exceeds ____________ milliamperes, the GFCI interrupts the current quickly enough to prevent electrocution.

j. Mechanical equipment must be positioned no closer than ____________ feet from overhead power lines.

Objective 13

Assignment Sheet 1—Identify and Describe Safety Violations

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Inspected all listed items	______
• Accurately described all safety violations	______

Basic Skills

Reading Writing Critical Thinking

Directions

Complete the following electrical safety checklist for your school shop area. After you have inspected all of the items described, describe the safety violations for those you have checked in the "No" column.

		Place a (✓) in the appropriate box. Yes	No
a.	Cords on all machines are properly connected.	☐	☐
b.	Extension cords are used within designated rating.	☐	☐
c.	Extension cords are in good working condition.	☐	☐
d.	Shop area is properly wired.	☐	☐
e.	All electrical hand tools are properly grounded.	☐	☐
f.	All electrical equipment is properly grounded.	☐	☐
g.	Ground fault interrupters are present and in working order.	☐	☐
h.	All machines are marked with safety operations.	☐	☐
i.	Shop safety rules are posted.	☐	☐

Assignment Sheet 1

j. Safety lanes are marked using proper color designations. ☐ ☐

k. Fire extinguishers are properly charged and service. ☐ ☐

l. Fire extinguishers are easily accessible. ☐ ☐

m. Areas around electrical equipment are clean and dry. ☐ ☐

n. Areas around water fountains are clean and dry. ☐ ☐

o. First aid kit is properly stocked and marked for identification. ☐ ☐

p. Emergency numbers are posted at phone. ☐ ☐

q. General housekeeping practices are observed. ☐ ☐

Safety Violations

Objective 14

Assignment Sheet 2—Solve Problems Concerning Electrical Safety Practices

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accurately interpreted circumstances	_____
• Took realistic and safe course of action	_____

Basic Skills

Reading Writing Critical Thinking

Directions

Read the following brief problems concerning electrical safety practices. Describe the appropriate safe course of action to take.

a. You are working on a project in the school shop and the person next to you shorts out his project and it catches fire. What are the safety procedures you should take?

b. While working at the project house, you hear a shout and turn to see that a fellow worker has fallen to the floor with an electric line under his body. What is the very first thing you should do?

c. You are called out on a job after a storm to repair an electric pump in a basement which is flooded with water. List the things you should do before repairing the pump.

Objective 27

Assignment Sheet 1—Add Whole Numbers

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	**Rating**
- Completed all problems and showed work	______
- Labeled answers with correct unit of measurement	______
- Computed a minimum of 18 of the 20 answers correctly per Assignment Sheet 1 answers	______

Basic Skills

Reading Mathematics

Directions

Will vary with assignment.

Solve the following addition problems.

Examples:

$$\begin{array}{r} 5 \\ \underline{+\,10} \\ 15 \end{array} \qquad \begin{array}{r} 1 \\ 67 \\ \underline{+\,25} \\ 92 \end{array} \leftarrow \text{Carried Digit} \qquad \begin{array}{r} 11 \\ 539 \\ 333 \\ \underline{+\,432} \\ 1304 \end{array} \leftarrow \text{Carried Digits}$$

a. Solve each of the following addition problems. Show your work.

$$1.\ \begin{array}{r} 2 \\ \underline{+\,9} \end{array} \qquad 2.\ \begin{array}{r} 8 \\ \underline{+\,8} \end{array} \qquad 3.\ \begin{array}{r} 7 \\ \underline{+\,6} \end{array} \qquad 4.\ \begin{array}{r} 15 \\ \underline{+\,8} \end{array} \qquad 5.\ \begin{array}{r} 81 \\ \underline{+\,27} \end{array}$$

$$6.\ \begin{array}{r} 7 \\ 38 \\ \underline{+\,43} \end{array} \qquad 7.\ \begin{array}{r} 55 \\ 88 \\ \underline{+\,99} \end{array} \qquad 8.\ \begin{array}{r} 341 \\ 428 \\ \underline{+\,769} \end{array} \qquad 9.\ \begin{array}{r} 472 \\ 564 \\ \underline{+\,881} \end{array} \qquad 10.\ \begin{array}{r} 9876 \\ 5432 \\ \underline{+\,1122} \end{array}$$

b. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. The wiring specialist has 12 receptacles. He has ordered and received 8 additional receptacles. How many total receptacles does he have?

   Total receptacles = ______________

2. A fixture has a 34-candlepower bulb, a 26-candlepower bulb, a 9-candlepower bulb, and a 15-candlepower bulb. Find the total candlepower.

   Total candlepower = ______________

3. Tonja ordered the following number of fasteners on different dates: 256, 62, 575, and 242. How many fasteners should she be billed for?

   Number of fasteners = ______________

4. If an electricial technician paid $480 for a lighting fixture, $13 for conduit, $81 for tools and equipment, and $35 for supplies, what was the total cost?

   Total cost = ______________

5. On a major electrical installation, Bill worked 28 hours, Eliot worked 16 hours, and Shanedra worked 42 hours. What are the total hours worked on this job?

   Total hours worked = ______________

6. In a toolbox are 23 socket wrenches, 14 open-end wrenches, 11 tubing wrenches, and 5 channel-lock wrenches. How many wrenches are in the toolbox?

   Number of wrenches in toolbox = _______________

7. There are 13 large boxes in the tool room, 7 medium boxes, and 11 small boxes. How many boxes are in the tool room?

   Number of boxes = _______________

8. Six installations were completed by electricians. The number of feet of conductors used is 65, 75, 69, 81, 57, and 76. What is the total number of feet used?

   Number of feet used = _______________

9. An electrician installs some outdoor antenna wiring measuring 40 feet, 60 feet, 37 feet, and 145 feet. How many feet of wiring were installed?

   Total number of feet = _______________

10. Conductor in a circuit measures 18 inches, 25 inches, 19 inches, and 46 inches. What is the total length of conductor in the circuit (in inches)?

    Total number of inches = _______________

Objective 28

Assignment Sheet 2—Subtract Whole Numbers

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 20 of the 24 answers correctly per Assignment Sheet 2 answers	______

Basic Skills

Reading

Mathematics

Directions

Will vary with assignment.

Solve the following addition problems.

Examples:

12	Original Number	57	Original Number
−7	Subtracted Number	−35	Subtracted Number
+5	Answer (Difference)	+22	Answer (Difference)
12	Check Answer (Same as Original Number)	57	Check Answer

a. Solve each of the following subtraction problems. Check your answer by adding the difference to the subtracted number. Show your work.

1. 9 − 5
2. 15 − 8
3. 75 − 22
4. 453 − 47
5. 742 − 318

6. 981 − 698
7. 1420 − 245
8. 3459 − 1649
9. 55722 − 4272
10. 98679 − 8957

b. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks. Check your answers by adding the difference to the subtracted number.

1. If a shop needs 172 drop cloths and it has 46, how many more drop cloths would the shop need?

   Number of drop cloths needed = ______________

2. If there are 18 octagon boxes on inventory and you use 6 of them, how many are left?

   Number of octagon boxes left = ______________

3. Angela worked 33 hours on 2 major installations, and Henry worked 56 hours on similar installations. How many more hours did Henry work than Angela?

   Difference in hours worked = ______________

4. In the first year of operation, an electrical shop handled 1219 jobs. During the second year, the jobs increased to 2167. How many more jobs did the shop do the second year?

   Difference in jobs = ______________

5. To install an overhead fixture takes 65 minutes. If you have already worked 27 minutes, how much longer will you need to work?

   Difference in minutes worked = ______________

6. Mr. Perez, the instructor, has 240 bar hangers in stock. If 98 are needed during the first semester course, how many are left for the second semester?

   Number of bar hangers left = ______________

7. If the average length of conduit used in a week is 2100 inches and you used 2310 inches, how much above average is the length of conduit you used?

   Inches used above average length = ______________

8. You can work only 13 hours this week. The following week you can work 6 hours. How much additional time will it take the third week if the job will take 27 total hours?

   Additional hours required = ______________

9. The transportation pool uses 250 liters of oil per semester. There are only 127 liters of oil in the storage room. How many more liters will be needed for the semester?

   Liters needed = ______________

10. Determine the number of kilometers traveled for each of five weeks from the odometer readings below.

Week	1	2	3	4	5
Reading (start)	32,119	32,899	33,988	35,976	37,065
Reading (end)	32,899	33,988	35,976	37,065	39,001

Week 1 ______________ km

Week 2 ______________ km

Week 3 ______________ km

Week 4 ______________ km

Week 5 ______________ km

Objective 29

Assignment Sheet 3—Multiply Whole Numbers

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 18 of the 20 answers correctly per Assignment Sheet 3 answers	______

Basic Skills

Reading Mathematics

Directions

Solve the following multiplication problems.

Examples:

$$\begin{array}{r} \\ 8 \\ \underline{\times\ 7} \\ 56 \end{array} \qquad \begin{array}{rl} 1 & \leftarrow \text{Carried Digit} \\ 53 & \\ \underline{\times\ 4} & \\ 212 & \end{array} \qquad \begin{array}{rl} 11 & \leftarrow \text{Carried Digits} \\ 756 & \\ \underline{\times\ 312} & \\ 1512 & \leftarrow \text{First Partial Product} \\ 756 & \leftarrow \text{Second Partial Product} \\ \underline{2268} & \leftarrow \text{Third Partial Product} \\ 235872 & \leftarrow \text{Product} \end{array}$$

a. Solve each of the following multiplication problems. Show your work.

1. $\begin{array}{r} 6 \\ \underline{\times\ 7} \end{array}$ 2. $\begin{array}{r} 9 \\ \underline{\times\ 8} \end{array}$ 3. $\begin{array}{r} 54 \\ \underline{\times\ 6} \end{array}$ 4. $\begin{array}{r} 721 \\ \underline{\times\ 4} \end{array}$ 5. $\begin{array}{r} 1682 \\ \underline{\times\ 5} \end{array}$

6. $\begin{array}{r} 78 \\ \underline{\times\ 26} \end{array}$ 7. $\begin{array}{r} 453 \\ \underline{\times\ 47} \end{array}$ 8. $\begin{array}{r} 314 \\ \underline{\times\ 527} \end{array}$ 9. $\begin{array}{r} 2143 \\ \underline{\times\ 235} \end{array}$ 10. $\begin{array}{r} 4123 \\ \underline{\times\ 1324} \end{array}$

b. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. There are 4 conductors in a duct. How many conductors are in 8 ducts?

   Number of conductors = _______________

2. There are 24 metallic boxes in a case. How many boxes are in 4 cases?

   Number of boxes = _______________

3. There are 500 dry-wall screws in a box. How many are in 6 boxes?

   Number of screws = _______________

4. If it takes 4 new faceplates per installation, how many faceplates will be needed for 6 installations?

   Faceplates needed = _______________

5. There are 16 electrical wiring students working on installations. If each student works 8 hours, what are the total hours spent?

   Total hours spent = _______________

6. If a can of lubricant costs $6 per pound, how much will 58 pounds cost?

   Total cost of lubricant = _______________

7. It takes 35 minutes to complete an installation. How much time will it take to complete 9 installations of the same type?

   Total minutes required = ______________

8. How many of the school's cars can be washed in an automatic car wash in 9 hours if 15 can be washed in 1 hour?

   Total cars washed = ______________

9. Figure the amount of time worked in 4 weeks by 12 electrical wiring specialists who work 30 hours each week.

   Hours worked = ______________

10. A truck travels 42 kilometers an hour for 6 hours daily for 19 days. Another truck travels 37 kilometers an hour for 6 hours daily for 23 days. A third truck travels 39 kilometers an hour for 6 hours daily for 22 days. What is the total kilometers of the three trucks?

    Total kilometers = ______________

Objective 30

Assignment Sheet 4—Divide Whole Numbers

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 14 of the 16 answers correctly per Assignment Sheet 4 answers	______

Basic Skills

Reading Mathematics

Directions

Solve the following division problems.

Examples:

$$\text{Divisor}\,\overline{)\text{Original Number}}^{\;\text{Answer}}$$

$$\begin{array}{r} 324 \\ 3\overline{)972} \\ \underline{9} \\ 7 \\ \underline{6} \\ 12 \\ \underline{12} \end{array}$$

$$\begin{array}{rl} 0111 & \text{Answer} \\ 51\overline{)5678} & \\ \underline{51} & \\ 57 & \\ \underline{51} & \\ 68 & \\ \underline{51} & \\ 17 & \text{Remainder} \end{array}$$

Check:

$$\begin{array}{rl} 111 & \text{Answer} \\ \times\ \underline{51} & \text{Divisor} \\ 111 & \\ \underline{555} & \\ 5661 & \\ +\ \underline{17} & \text{Remainder} \\ 5678 & \text{Original Number} \end{array}$$

Assignment Sheet 4

a. Solve each of the following division problems. Check your answers by multiplying the divisor by the original number. Show your work.

1. $2\overline{)8}$
2. $6\overline{)48}$
3. $9\overline{)819}$
4. $4\overline{)1248}$
5. $13\overline{)39}$
6. $66\overline{)198}$
7. $84\overline{)5212}$
8. $124\overline{)345}$
9. $464\overline{)829}$
10. $746\overline{)2872}$

b. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. If a can of dry-wall screws holds 5 pounds, how many cans can be filled from a 55-pound drum?

   Number of cans = ______________

2. Clark received $418 for an installation. He worked 19 hours on the job. How much did he make per hour?

   Amount earned per hour = ______________

3. How many 4-screw boxes can be installed using a case containing 416 screws?

   Number of 4-screw boxes = ______________

4. If Vonda can install 4 GFCIs a day, how many days will it take her to install 92 GFCIs?

   Number of days = ______________

5. New electrical measuring equipment cost $13,104. How much will the school's monthly payments be if the equipment is financed over a 14-month period?

   Monthly payments = ______________

6. An electrican has 3,828 business cards. He gives away 116 each day. How many days' supply does he have?

   Number of days = ______________

Objective 31

Assignment Sheet 5—Reduce Fractions to Lowest Terms

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 8 of the 10 answers correctly per Assignment Sheet 5 answers	______

Basic Skills

Reading Mathematics

Directions

Reduce the following fractions to their lowest terms.

Example: $\frac{9}{12} = \frac{9 \div 3}{12 \div 3} = \frac{3}{4}$ $\frac{12}{32} = \frac{12 \div 4}{32 \div 4} = \frac{3}{8}$

A. $^4/_8$ = __________

B. $^8/_{16}$ = __________

C. $^2/_2$ = __________

D. $^4/_{16}$ = __________

E. $^{12}/_{48}$ = __________

F. $^9/_{24}$ = __________

G. $^{16}/_{32}$ = __________

H. $^2/_4$ = __________

I. $^9/_{12}$ = __________

J. $^{50}/_{100}$ = __________

Objective 32

Assignment Sheet 6—Convert Fractions and Mixed Numbers

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	**Rating**
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 30 of the 35 answers correctly per Assignment Sheet 6 answers	______

Basic Skills

Reading Mathematics

Directions

Convert the following fractions and mixed numbers. Reduce to lowest terms when possible.

a. Distinguish among the following fractions by writing a "P" in the blanks before a proper fraction, an "I" before an improper fraction, and an "M" in the blanks before a mixed number.

_____ 1. 1/2

_____ 2. 3 7/8

_____ 3. 16/2

_____ 4. 3 1/8

_____ 5. 1/4

_____ 6. 1/1

_____ 7. 7/2

_____ 8. 8 1/2

_____ 9. 4/4

_____ 10. 9 3/16

_____ 11. 5 1/2

_____ 12. 9/8

_____ 13. 9/4

_____ 14. 1/8

_____ 15. 16 3/4

b. Convert each of the following mixed numbers to improper fractions. Reduce to lowest terms when possible.

1. 3 1/4 = ______________
2. 4 1/2 = ______________
3. 7 3/4 = ______________
4. 8 1/2 = ______________
5. 6 1/8 = ______________
6. 5 2/4 = ______________
7. 4 1/4 = ______________
8. 8 1/2 = ______________
9. 9 1/4 = ______________
10. 16 1/2 = ______________

c. Convert each of the following improper fractions to mixed numbers. Reduce to lowest terms when possible.

1. 7/4 = ______________
2. 9/2 = ______________
3. 6/4 = ______________
4. 15/8 = ______________
5. 19/16 = ______________
6. 11/8 = ______________
7. 75/32 = ______________
8. 5/2 = ______________
9. 15/4 = ______________
10. 33/16 = ______________

Objective 33

Assignment Sheet 7—Add Fractions

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Completed all problems and showed work	_____
• Labeled answers with correct unit of measurement	_____
• Computed a minimum of 17 of the 19 answers correctly per Assignment Sheet 7 answers	_____

Basic Skills

Reading Mathematics

Directions

Adding like fractions:

Examples: Add $^{3}/_{4}$ and $^{3}/_{4}$.

1. Add the numerators.

   Example: $3 + 3 = 6$

2. Place answer over common denominator and reduce to lowest terms if necessary.

   Example: $^{6}/_{4} = 1\,^{2}/_{4} = 1\,^{1}/_{2}$ Answer

Adding unlike fractions:

Examples: Add $^{1}/_{4}$ and $^{7}/_{8}$.

1. Change to equivalent fractions with lowest common denominator.

   Example: $^{7}/_{8}$ remains the same, as 8 is lowest common denominator.

   $^{1}/_{4}$ is multiplied by $^{2}/_{2}$, or $^{1}/_{4} \times {}^{2}/_{2} = {}^{2}/_{8}$.

2. Add the numerators.

   Example: $\underline{7 + 2} = {}^{9}/_{8}$

3. Change improper fraction to mixed number and reduce to lowest terms if necessary.

   Example: 9/8 = 9 ÷ 8 = 1 1/8 Answer

Adding mixed numbers:

Example: Add 3 5/8 + 7 5/8.

1. Add numerators

   Example: $\frac{5+5}{8} = 10/8$

2. Change improper fraction to mixed number and reduce to lowest terms if necessary.

   Example: 10/8 = 10 ÷ 8 = 1 2/8 = 1 1/4

3. Add whole numbers and fractions.

   Example: 3 + 7 + 1 + 1/4 = 11 1/4 Answer

a. Add the following fractions. Show your work in the space provided below the problems. Reduce to lowest terms if necessary. Write your answers on the blanks beside the problems.

1. 7/16 + 5/16 = ________

2. 5/8 + 7/8 = ________

3. 1/4 + 2/8 = ________

4. 4/16 + 3/4 = ________

5. 9/16 + 5/8 = ________

6. 5/8 + 5/32 = ________

7. 3/4 + 5/32 = ________

8. 7/8 + 6/16 = ________

9. 9/16 + 3/4 = ________

10. 4/4 + 25/32 = ________

b. Solve the following problems. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. Add the lengths of two wires that are 6 $^1/_2$ inches and 8 $^1/_4$ inches.

   Total length in inches = ____________________

2. Carlos worked 4 $^1/_2$ hours before lunch and 3 $^1/_4$ hours after lunch. How many hours did Carlos work?

   Total hours worked = ____________________

3. Add the lengths of three extension tools that are 2 $^1/_8$ inches, 3 $^1/_4$ inches, and 1 $^{13}/_{16}$ inches.

   Total length in inches = ____________________

4. Three pieces of conductor have lengths of 6 $^5/_8$ inches, 6 $^3/_4$ inches, and 6 $^1/_4$ inches. What is the total length of the three pieces of conductor?

   Total length in inches = ____________________

5. In learning to read an English rule, Taro located 4 $^7/_8$ inches on the rule, Gustav read 3 $^{15}/_{16}$ inches, and Li-Chen located 4 $^1/_4$ inches. How many total inches were located?

   Total inches = ____________________

6. Add three conductor segments 17 $^{15}/_{16}$ inches, 16 $^{3}/_{4}$ inches, and 25 $^{3}/_{8}$ inches.

   Combined segments in inches = ____________________

7. Three dimensions are 1 $^{11}/_{16}$ inches, 2 $^{3}/_{8}$ inches, and 2 $^{3}/_{4}$ inches. What is the combined dimension?

   Combined dimension in inches = ____________________

8. A container of petroleum solvent has 1 $^{1}/_{2}$ liters in it. Sally adds 1 $^{3}/_{4}$ liters. How many liters are now in the container?

   Total liters of solvent = ____________________

9. An electrician worked 5 $^{7}/_{8}$ hours, 3 $^{3}/_{4}$ hours, and 7 $^{7}/_{16}$ hours on three installations. How many total hours did the electrician work?

   Total hours worked = ____________________

Objective 34

Assignment Sheet 8—Subtract Fractions

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 38 of the 43 answers correctly per Assignment Sheet 8 answers	______

Basic Skills

Reading Mathematics

Directions

Subtracting like fractions:

Examples: Subtract $^{1}/_{16}$ from $^{7}/_{16}$.

1. Subtract smaller numerator from lager numerator.

   Example: $7 - 1 = 6$

2. Place answer over common denominator.

   Example: $^{6}/_{16}$

3. Reduce to lowest terms if required.

   Example: $^{6}/_{16} = {}^{3}/_{8}$ Answer

Subtracting unlike fractions:

Example: Subtract $^{1}/_{2}$ from $^{3}/_{4}$.

1. Change to like fractions.

   Example: $^{3}/_{4}$ remains the same because 4 is the common denominator.

   $^{1}/_{2}$ is multiplied by $^{2}/_{2}$, or $^{1}/_{2} \times {}^{2}/_{2} = {}^{2}/_{4}$.

2. Subtract as for like fractions and reduce to lowest terms if required.

   Example: $^{3}/_{4} - {}^{2}/_{4} = {}^{1}/_{4}$ = Answer

Subtracting mixed numbers:

Example: Subtract 3 $^{1}/_{2}$ from 5 $^{1}/_{8}$

1. Change mixed numbers to like fractions.

   Example: $3\ ^{1}/_{2} - 3\ ^{4}/_{8}$

2. Borrow a 1 from the original whole number if needed, and convert the 1 to a like fraction, and add it to the smaller fraction.

   Note: This step is needed only if the like fraction in the original number is smaller than the like fraction in the subtracted number.

   Example: $5\ ^{1}/_{8} - 1\ ^{4}/_{8} = (4\ ^{8}/_{8} + {}^{1}/_{8}) - 3\ ^{4}/_{8} = 4\ ^{9}/_{8} - 3\ ^{4}/_{8}$

3. Subtract whole number from whole number and like fraction from like fraction, and reduce answer to lowest terms if required.

   Example: $4\ ^{9}/_{8} - 3\ ^{4}/_{8} = 1\ ^{5}/_{8}$ Answer

Subtracting a fraction from a whole number:

Example: $4 - {}^{3}/_{16}$

1. Borrow 1 from whole number.

   Example: $4 - 1 = 3$

2. Change borrowed 1 to like fraction.

   Example: $1 = {}^{16}/_{16}$

3. Subtract as for like fractions and reduce answer to lowest terms if required.

   Example: $3\ ^{16}/_{16} - {}^{3}/_{16} = 3\ ^{13}/_{16}$ Answer

Assignment Sheet 8

a. Subtract the proper fractions given below. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. 3/4 – 3/16 = ____________

2. 7/8 – 1/4 = ____________

3. 30/32 – 3/4 = __________

4. 25/32 – 5/8 = __________

5. 7/8 – 2/16 = ____________

6. 15/16 – 3/8 = ____________

7. 1/2 – 7/16 = ____________

8. 3/4 – 3/8 = ____________

9. 13/16 – 9/32 = ____________

10. 7/8 – 6/16 = ____________

b. Subtract the following fractions from whole numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. 4 – 3/4 = ____________

2. 7 – 15/16 = __________

3. 32 – 13/32 = __________

4. 175 – 4/5 = ____________

5. 12 – 61/64 = __________

Assignment Sheet 8

c. Subtract the following mixed numbers from whole numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $2 - 1\,^{1}/_{3} =$ ________
2. $3 - 1\,^{3}/_{8} =$ ________
3. $18 - 9\,^{7}/_{8} =$ ________
4. $3 - 1\,^{21}/_{32} =$ ________
5. $27 - 1\,^{5}/_{16} =$ ________
6. $14 - 6\,^{3}/_{4} =$ ________
7. $5 - (3\,^{5}/_{32} + 1\,^{9}/_{32}) =$ ______
8. $8 - (1\,^{1}/_{4} + 5\,^{5}/_{8} + ^{1}/_{16}) =$ ____
9. $4 - 3\,^{1}/_{3} =$ ________
10. $42 - 3\,^{7}/_{16} =$ ________

d. Subtract the following mixed numbers. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. $1\,^{3}/_{5} - 1\,^{1}/_{5} =$ ______
2. $72\,^{6}/_{16} - 22\,^{7}/_{16} =$ ____
3. $7\,^{5}/_{6} - 2\,^{1}/_{6} =$ ______
4. $18\,^{7}/_{8} - 9\,^{3}/_{8} =$ ______
5. $35\,^{5}/_{8} - 8\,^{1}/_{2}$ ________
6. $5\,^{1}/_{4} - (1\,^{1}/_{8} + 1\,^{7}/_{8}) =$ ____
7. $12\,^{1}/_{2} - (7\,^{1}/_{4} + 3\,^{1}/_{8}) =$ __
8. $4\,^{29}/_{32} - 1\,^{19}/_{32} =$ ________
9. $5\,^{15}/_{32} - 2\,^{31}/_{32} =$ ________
10. $8\,^{1}/_{16} - 4\,^{7}/_{8} =$ ________

e. Solve the following word problems. Show your work in the spaces provided. Reduce to lowest terms if necessary. Write your answers on the blanks.

1. Ross had a $^7/_8$-inch wrench. He needed a $^3/_4$-inch wrench. How much difference is there in the size of the wrenches?

   Differences in inches = ____________________

2. Anita worked 5 $^1/_4$ hours on an installation, and Don worked 4 $^1/_2$ hours on the same installation. How much faster did Don work than Anita?

   Difference in hours = ____________________

3. An outlet is to be installed 4 $^1/_2$ inches from the floor. Two pieces of decorative baseboard will be installed under the outlet. If one piece of baseboard is 1 $^5/_8$ inches wide, how wide must the second piece be to touch the outlet?

   Width of baseboard in inches = ____________________

4. Three pieces of conductor are cut from a piece 35 $^1/_2$ inches long. The lengths are 7 $^1/_4$ inches, 11 $^3/_8$ inches, and 6 $^1/_2$ inches. If $^3/_8$ inch of conductor is wasted in cutting, how much conductor is left?

   Length of conductor left in inches = ____________________

5. A piece of rigid metal conduit is 32 $1/2$ inches long. Short pieces of the following lengths are cut from it: 6 $1/2$ inches, 5 $1/4$ inches, 8 $13/16$ inches, and 10 $9/16$ inches. How much conduit is left?

   Amount of conduit left in inches = ____________________

6. A wash up tank has 16 $3/10$ gallons of solvent in it. After using 9 $3/4$ gallons, how many gallons will be left?

   Number of gallons = ____________________

7. A container of solvent holds 4 $1/4$ liters. How much solvent is left after using $1/2$ liter to clean terminals before soldering?

   Combined segments in inches = ____________________

8. A conductor is $1/2$ inch by 10 inches. If 1 $3/8$ inches are cut from its length, what will be the final length of the conductor?

   Conductor length in inches = ____________________

Objective 35

Assignment Sheet 9—Multiply Fractions

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 9 of the 11 answers correctly per Assignment Sheet 9 answers	______

Basic Skills

Reading Mathematics

Directions

Solve the following multiplication problems.

Example:

$\frac{2}{3} \times \frac{3}{4}$ becomes $\frac{2 \times 3}{3 \times 4} = \frac{6}{12} = \frac{1}{2}$

a. Multiply the following fractions. Convert mixed fractions where needed and reduce answers to lowest terms.

1. $\frac{1}{2} \times \frac{3}{4} =$ __________
2. $1\frac{1}{2} \times 2\frac{1}{4} =$ __________
3. $\frac{7}{8} \times \frac{2}{3} =$ __________
4. $\frac{1}{4} \times \frac{1}{3} \times \frac{1}{2} =$ __________
5. $\frac{3}{8} \times \frac{5}{16} =$ __________
6. $\frac{1}{2} \times 6\frac{1}{2} =$ __________
7. $1\frac{1}{3} \times 2\frac{1}{4} \times \frac{1}{2} =$ __________
8. $2\frac{3}{4} \times 6\frac{1}{8} =$ __________

b. Solve the following word problems. Show your work in the space provided. Write your answers on the blanks.

1. A certain cleaning agent requires mixing 3/4 gallon solvent and 1/4 gallon water to make a gallon of cleaning agent. How much solvent should a worker use if she needs to mix only 1/3 gallon of the cleaning agent?

   Amount of agent = ____________________

2. There are 296 dry-wall screws per pound. How many screws are there in 1/4 pound?

   Number of screws = ____________________

3. After completing an installation, a contractor has 8 2/3 feet of conductors left in three different types. If one-half of the wires are neutral (green), how many neutral wires are there?

   Number of neutral wires = ____________________

Objective 36

Assignment Sheet 10—Add Decimal Numbers

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 35 of the 40 answers correctly per Assignment Sheet 10 answers	______

Basic Skills

Reading

Mathematics

Directions

Solve the following decimal addition problems.

a. Write the name of the place for each *underlined* digit.

__________ 1. $867.\underline{4}3$

__________ 2. $6.3\underline{7}892$

__________ 3. $1.000\underline{8}$

__________ 4. $6.239\underline{5}$

__________ 5. $0.47\underline{6}$

b. Write the name of the place for the last digit in each of the following numbers.

__________ 1. 0.38

__________ 2. 0.4678

__________ 3. 321.9

__________ 4. 427.389

__________ 5. 44.67

c. Underline the digit that is in the place named in italics.

1.	46.3826	*Hundredths*	11.	5230.867	*Thousandths*
2.	35.0038	*Ten thousandths*	12.	587.029	*Ones (units)*
3.	148.296	*Tenths*	13.	0.298	*Hundredths*
4.	6758.23	*Hundredths*	14.	329.768	*Tens*
5.	91.4082	*Thousandths*	15.	52.694	*Thousandths*
6.	204.37	*Tens*	16.	498.276	*Tenths*
7.	14.0079	*Ones (units)*	17.	0.5296	*Ten thousandths*
8.	208.097	*Hundredths*	18.	468.539	*Hundredths*
9.	5.23981	*Thousandths*	19.	324.06	*Tenths*
10.	502.967	*Tenths*	20.	567.8	*Ones (units)*

d. Set up the following groups of numbers in columns. Add each column, carrying when necessary and placing the decimal point correctly.

1. 0.024 + .165

2. 87.3 + 370

3. 15.127 + 3.4 + .0091 + 236.87

4. 195.7 + 83 + 9.006

5. .5280 + 435 + 179.50 + 1.9

e. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. Motoaki earned $22.50 on an installation, and Maria earned $16.50. How much did they earn together?

   Total amount earned = ______________

2. On an installation, labor costs $54.65, parts cost $16.30, and the tax is $3.38. What is the total cost of the job?

   Total cost = ______________

3. Octavia worked four days on a certain project. She worked 6.8 hours Monday, 7.4 hours Tuesday, 5.3 hours Wednesday, and 4.4 hours Thursday. How many total hours did she work?

   Total hours worked = ______________

4. Frank was cleaning out the storage bin. He found three partially used bottles of solvent, each containing the following amounts: 6.7 liters, 12.0 liters, and .5 liters. How many total liters of solvent were stored?

   Total liters of solvent = ______________

5. In one month, an electrical contractor has the following expenses: equipment and supplies, $286.96; fixtures, $142.37; electric bill, $160.16; telephone, $116.27; and labor, $15,312.50. What was the contractor's total monthly expenditure?

   Total monthly expense = ______________

Objective 37

Assignment Sheet 11—Subtract Decimal Numbers

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Completed all problems and showed work	_____
• Labeled answers with correct unit of measurement	_____
• Computed a minimum of 12 of the 15 answers correctly per Assignment Sheet 11 answers	_____

Basic Skills

Reading Mathematics

Directions

Solve the following decimal subtraction problems.

a. Set up each of the following problems in column form. Subtract and check your work. Remember, when you subtract decimals, the decimal points must be aligned.

1. 868.87 – 516.89 = __________

2. 567 – 19.856 = __________

3. 198 – 56.987 = __________

4. 567.94 – 59.78 = __________

5. $815.23 – $65.98 = __________

6. $20.03 – $15.88 = ________

7. 694.7 – 24.3 = ________

8. 5,000 – 892.66 = ________

9. $15 – $12.53 = ________

10. $219.30 – $21.85 = ________

b. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. An electrical contractor received $8438.64 in December, and paid out $5121.32 in January. How much profit did the shop make?

   Profit = ________________

2. It takes 20.5 hours to finish a job. Sean has worked 6 hours. How much longer will it take him to finish the job?

   Hours required to finish job = ________________

922

3. A length of metallic tubing 6.14 centimeters long was cut from a tube 8.98 centimeters in length. How much tubing was left?

   Centimeters of hose left = _______________

4. A water cooler holds 49.2 liters of water. After a day, workers have drunk 8.7 liters. How much water is left in the cooler?

   Liters of water in cooler = _______________

5. You have a piece of conduit with a length of 27.5 inches, but the conductors to be run in it are 55 inches long. How many more inches must the conduit be to accommodate the wires?

   Inches = _______________

Objective 38

Assignment Sheet 12—Multiply Decimal Numbers

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 16 of the 18 answers correctly per Assignment Sheet 12 answers	______

Basic Skills

Reading Mathematics

Directions

Solve the following decimal multiplication problems.

Example:
16.11 2 Decimal Places
x 2.2 1 Decimal Place
3222
3222
35.422 3 Decimal Places in Answer

a. Set up each of the following problems in column form and multiply. Locate the decimal point in the answer.

1. 2.64 x 3.1 = __________

2. 120 x 0.33 = __________

3. 2.25 x 0.51 = __________

4. 35 x 8.5 = __________

5. 26.4 x 3.8 = __________

6. 7.02 x 0.92 = __________

7. 0.83 x 0.55 = __________

8. 28.2 x 0.9 = __________

9. 0.069 x 0.01 = __________

10. 7.52 x 3.01 = __________

b. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. A tool kit is placed on sale for 25 percent off. By what amount is the price reduced if the regular price is $1349.80?

   Note: Twenty-fiver percent is the same as the decimal .25.

   Price reduction = ________________

2. The average cost of a replacement part is $41.25. During the year, the electrician installs 150 such parts. What is the total cost?

   Total average cost = ________________

3. What is the total distance traveled at 1.3 km/h if the trip took .6 hours?

   Kilometers traveled = ________________

4. What is the total length of 7 pieces of wiring if each piece is .04 meter long?

   Length in meters = ________________

5. What is the cost of 15 gallons of solvent at $1.13 per gallon?

   Cost = ________________

6. If faceplates cost 78¢ each, what is the cost of 2 dozen faceplates?

   Cost = ________________

7. An electrical contractor is adding a work area 16.4 meters long by 11.5 meters wide. How many square meters large will the area be?

   Size in square meters = ________________

8. Carmelita completed 6 wiring installations in the last five days. She worked 5.6 hours the first day, 3.8 hours the second day, 4.4 hours the third day, 2 hours the fourth day, and 6.6 hours the fifth day. Using this 5-day period as an average, how many hours would Carmelita work over a 15-day period?

   Hours = ________________

Objective 39

Assignment Sheet 13—Divide Decimal Numbers

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 13 of the 15 answers correctly per Assignment Sheet 13 answers	______

Basic Skills

Reading Mathematics

Directions

Solve the following decimal division problems.

a. Set up each of the following problems in column form and multiply. Locate the decimal point in the answer.

1. 4.5 ÷ 0.5 = __________

2. 4.96 ÷ 0.4 = __________

3. 19.8 ÷ 0.6 = __________

4. 10.71 ÷ 0.07 = __________

5. 0.225 ÷ 0.15 = __________

6. 1.7608 ÷ 0.0062 = ______

7. 0.48 ÷ 0.6 = __________

8. 0.125 ÷ 0.25 = __________

9. 0.9 ÷ 0.003 = __________

10. 1.16 ÷ 2.9 = __________

b. Solve the following word problems. Show your work in the spaces provided. Write your answers on the blanks.

1. What is the approximate cost per fixture if the cost of twelve fixtures is $103.68?

   Approximate cost = ________________

2. How many hours did Jana work if she was paid a total of $681.75 at the rate of $22.50 per hour?

   Total hours = ________________

3. How many jobs can be completed in 21.12 hours if the average job takes .066 hours?

   Number of jobs = ________________

4. Curt spent $172.80 for equipment. What was the cost per piece if he bought eight pieces of equally priced equipment?

   Cost per piece = ________________

5. A shipment of 114 identical fixtures has arrived at Mr. Kinski's electrical shop. Mr. Kinski pays the carrier $544.98 for all of them. How much does 1 fixture cost?

   Cost of 1 fixture = ________________

Objective 40

Assignment Sheet 14—Convert Fractions and Percentages

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 54 of the 60 answers correctly per Assignment Sheet 14 answers	______

Basic Skills

Reading Mathematics

Directions

Solve the conversion problems.

a. Express each of the following fractions as decimal.

1. $^1/_8$ = __________
2. $^1/_4$ = __________
3. $^1/_2$ = __________
4. $^3/_4$ = __________
5. $^5/_8$ = __________
6. $^1/_{16}$ = __________
7. $^3/_{32}$ = __________
8. $^7/_8$ = __________
9. $^9/_{16}$ = __________
10. $^{15}/_{16}$ = __________

b. Express each of the following fractions as percentage.

1. $^{1}/_{4}$ = ________
2. $^{1}/_{2}$ = ________
3. $^{7}/_{10}$ = ________
4. $^{3}/_{4}$ = ________
5. $^{2}/_{2}$ = ________
6. $^{1}/_{10}$ = ________
7. $^{7}/_{8}$ = ________
8. $^{5}/_{10}$ = ________
9. $^{1}/_{3}$ = ________
10. $^{5}/_{8}$ = ________

c. Match the decimal numbers on the right with their correct equivalent fractions. Write the correct letters in the blanks.

_____	1.	$5\ ^{6}/_{10}$	a.	7.083
_____	2.	$1\ ^{2}/_{100}$	b.	5.006
_____	3.	$^{87}/_{1000}$	c.	78.3
_____	4.	$7\ ^{83}/_{1000}$	d.	0.087
_____	5.	$5\ ^{6}/_{100}$	e.	0.783
_____	6.	$5\ ^{6}/_{1000}$	f.	87.7
_____	7.	$78\ ^{3}/_{10}$	g.	5.6
_____	8.	$87\ ^{7}/_{10}$	h.	102.0
_____	9.	102	i.	5.06
_____	10.	$^{783}/_{1000}$	j.	1.02

d. Write decimal equivalents for each of the following fractions.

1. 63 9/10 = ________
2. 5 93/100 = ________
3. 5 93/1000 = ________
4. 5 93/10000 ________
5. 3 825/1000 = ________
6. 38 95/100 = ________
7. 38 95/1000 = ________
8. 42 3/10 = ________
9. 402 3/10 = ________
10. 897 97/100000 = ______

e. Express each of the following percentages as a fraction. Reduce to the lowest terms.

1. 50% = __________
2. 25% = __________
3. 33 1/3% = ________
4. 36% __________
5. 28% = __________
6. 14 2/7% = ________
7. 21% = __________
8. 75% = __________
9. 66 2/3% = ________
10. 70% = __________

f. Express each of the following percentages as a decimal.

1. 47% = __________
2. 15% = __________
3. 33.3% = ________
4. 62% __________
5. 75% = __________
6. 3% = __________
7. 16.8% =__________
8. 9% = __________
9. 10% = __________
10. 50% = __________

Objective 41

Assignment Sheet 15—Solve Percentage Problems

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 25 of the 29 answers correctly per Assignment Sheet 15 answers	______

Basic Skills

Reading Mathematics

Directions

Calculate the answer to the following percentage problems.

a. What does it mean to say 100 percent of the work is completed? ______.

____

b. There are usually 100 tools in the tool shed. Fourteen of them are missing. What percent of the tools is missing? ______________________

c. If 14 of the tools are missing in the above problem, how many are present? ______________________

What percent is present? ______________________

d. There are 100 boxes in a carton. Twenty-five boxes are what percent of the boxes in the carton? ______________________

e. There are 100 jobs on the agenda. Ninety-four have been completed. What percent of the jobs have been completed? ______________

f. If 94 of the jobs in the above problem have been completed, how many have not been? ______________________

What percent has not been completed? ______________________

g. If 11 percent of the students in a school are absent, what percent are present? ______________________

h. If 6 percent of the reamers that a store had in stock were not sold, what percent were sold? ______________________

i. If 60 percent of the electricians in town had assistants, what percent did not have assistants? ______________________

j. Bill has a set of electrician's tools. Ten percent of his tools are a year old, and 40 percent are over a year old. What percent are less than a year old?

____

k. Nicole has three types of screwdrivers—flat, Phillips, and square. Eighty percent of her screwdrivers are flat, and 15 percent are square. What percent are Phillips? ______________________

l. The Clarks spent 22 percent of their income for their business: 17 percent for tools, 15 percent for work clothes, and 8 percent for overhead. What percent was left for other things? ______________________

m. Hyun-lee has finished 75 percent of the job he is doing. What percent does he still have to do? ______________________

n. Marie has completed 40 percent of her training. What percent does she still have to do? ______________________

o. If you were told to complete 93 percent of the work, what percent would be left? ______________________

p. Solve each of the following percentage problems.

1. 3% of 72 is what number? __________
2. 5% of 18 is what number? __________
3. What number is 33 1/3% of 96? __________
4. 40% of 125 is what number? __________
5. 68% of 63.5 is what number? __________
6. What number is 12 1/2% of 140.8? __________
7. What number is 1% of 103? __________
8. What number is 37 1/2% of 152? __________
9. 50% of 32.8 is what number? __________
10. 7% of 163 is what number? __________

q. Solve the following percentage word problems.

1. There are 20 students in a class. Sixty percent of the students are boys. How many are boys. ____________________
2. One day 5 percent of the 20 electricians in Mr. Washington's group made perfect time completing a job. How many electricians made perfect time? ____________________
3. Contractor McGill bought a new power threader—regularly selling for $120—at a sale and saved 20 percent. How much money did he save? ____________________
4. The number of electricians at the meeting this year was 75 percent of what it was last week. Last year there were 800 electricians at the meeting. How many electricians were at the meeting this year?
____

Objective 42

Assignment Sheet 16—Calculate Area of Geometric Figures

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of 21 of the 24 answers correctly per Assignment Sheet 16 answers	______

Basic Skills

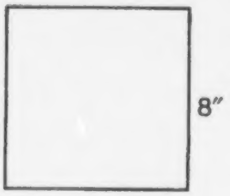
Reading Mathematics

Directions

Calculate area for the following problems.

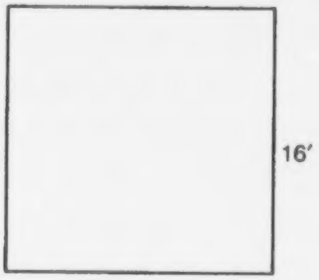
a. Calculate the area for each of the following squares.

1.



A = __________

2.



A = __________

3. Square = 15 feet

A = __________

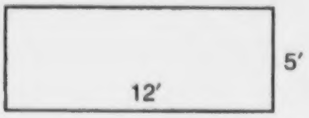
4. Square = 36 yards

A = __________

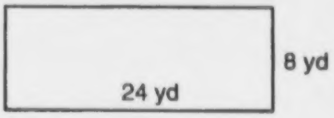
Assignment Sheet 16

b. Calculate area for each of the following rectangles.

1.



2.



A = ________

A = ________

3. L = 17″; W = 31″

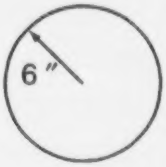
4. L = 16′; W = 62′

A = ________

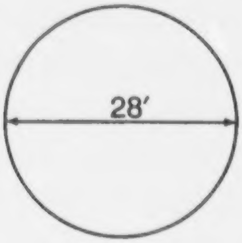
A = ________

c. Calculate area for each of the following circles. (Use π = 3.14.)

1.



2.



A = ________

A = ________

3. Radius = 16′

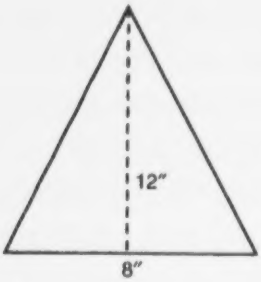
4. Diameter = 25 yards

A = ________

A = ________

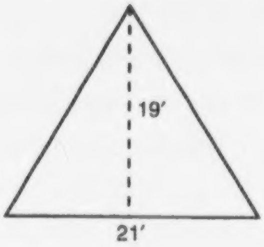
d. Calculate area for each of the following triangles.

1.



A = ______________

2.



A = ______________

3. b = 13″; h = 3″

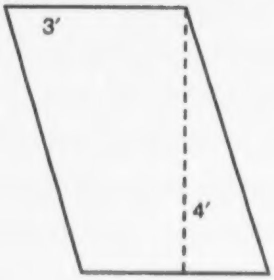
A = ______________

4. b = 24 yards; h = 15 yards

A = ______________

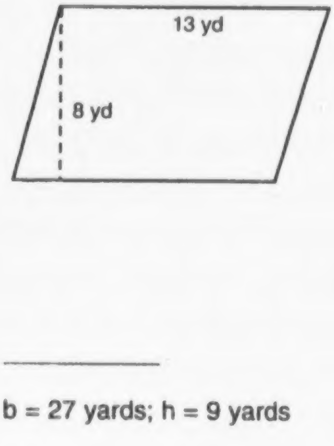
e. Calculate area for each of the following parallelograms.

1.



A = ______________

2.



A = ______________

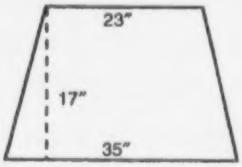
3. b = 16″; h = 16″

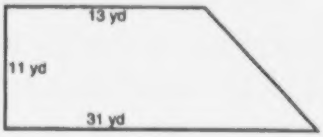
A = ______________

4. b = 27 yards; h = 9 yards

A = ______________

f. Calculate area for each of the following trapezoids.

1. 

2. 
13 yd
11 yd
31 yd

A = ____________

A = ____________

3. $h = 12'; b_1 = 9'; b_2 = 19'$

4. $h = 17$ yards; $b_1 = 39$ yards; $b_2 = 51$ yards

A = ____________

A = ____________

Objective 8

Focus Assignment—List and Price Electrician's Tools

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Determined tool pouch requirements	______
• Priced appropriate tools keeping size, design, and quality in mind	______

Basic Skills

Reading Critical Thinking Employability

Introduction

As an electrician, you will be responsible for purchasing the appropriate tools for your profession. Size, design, and quality are three factors that must be considered when selecting and purchasing tools. This assignment should raise your awareness about how much money you will need to spend on tools after graduating from the course.

Directions

With help from your instructor, list the tools electricians are required to carry (tool pouch requirements).

Focus Assignment Sheet

Obtain tool catalogs from your instructor or access tool catalogs on the internet. Price the selected tools and list the prices below. Be prepared to discuss your decisions in class.

Tool	Price

Total Cost

____

Objective 9

Assignment Sheet 1—Measure Objects Using a Tape Measure

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• All problems computed	______
• Eight of ten answers correct per assignment sheet answers	______

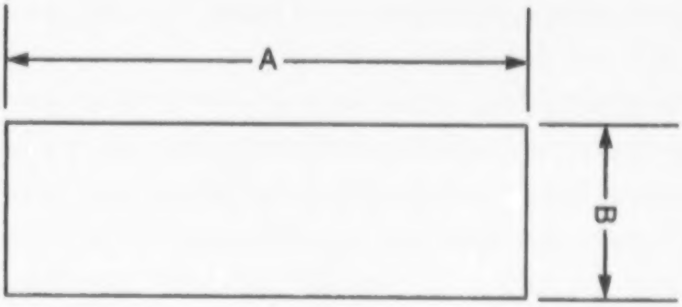
Basic Skills

Reading Mathematics Employability

Directions

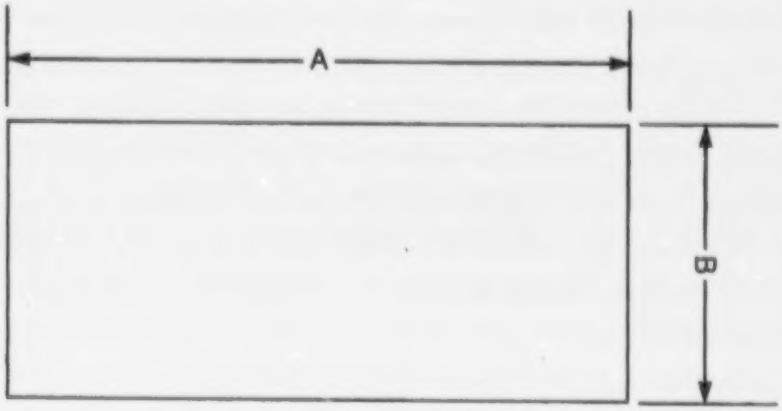
Using a tape measure with one-sixteenth inch graduations, measure the following objects.

a.



1. Length (A) is:
   a. 2 3/4″
   b. 3″
   c. 3 1/4″
   d. 4′

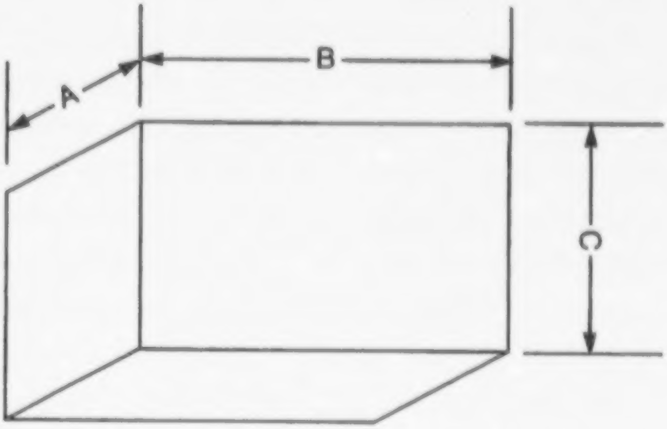
2. Height (B) is:
   a. 1″
   b. 5/8″
   c. 1 1/4″
   d. 2′



3. Length (A) is:
   a. 4 9/16″
   b. 4 1/8″
   c. 3 1/2″
   d. 3 9/16″

4. Height (B) is:
   a. 1 5/8″
   b. 1 3/4″
   c. 1 7/8″
   d. 2 5/8″

c.

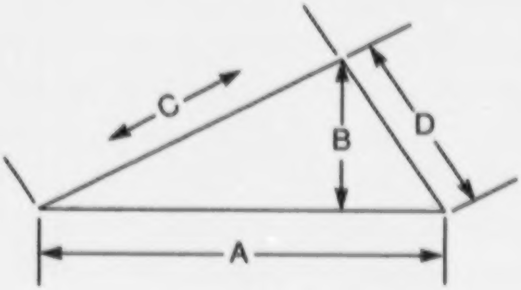


5. Length (A) is:
   a. 1 7/8″
   b. 9/16″
   c. 3/4″
   d. 7/8″

6. Length (B) is:
   a. 2″
   b. 2 1/8″
   c. 2 1/4″
   d. 2″

7. Height (C) is:
   a. 1 1/2″
   b. 1 1/4″
   c. 1 3/16″
   d. 1 5/16″

d.



8. Base (A) is:
   a. 2 5/16″
   b. 2 1/4″
   c. 2 1/2″
   d. 2 3/8″

9. Height (B) is:
   a. 7/8″
   b. 3/4″
   c. 15/16″
   d. 1/2″

10. Slope (C) is:
    a. 1 5/8″
    b. 1 1/2″
    c. 1 15/16″
    d. 1 3/4″

11. Slope (D) is:
    a. 1 1/8″
    b. 1 1/16″
    c. 1 1/4″
    d. 1 3/8″

Objective 10

Job Sheet 1—Clean and Lubricate an Adjustable Hand Tool

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pliers, or other adjustable hand tool
- Solvent
- Oil
- Safety glasses
- Lint-free cleaning cloth
- Rubber or plastic protective gloves
- Solvent tray

Note: An old rectangular cake pan works well.

Procedure

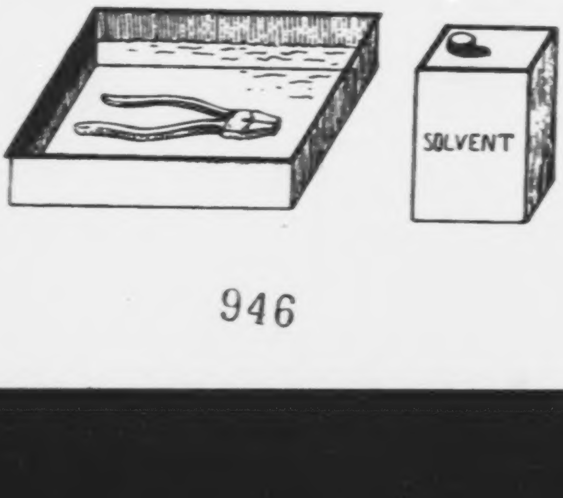
☐ 1. Put on protective gloves and safety glasses.

☐ 2. Lay pliers in tray.

☐ 3. Pour solvent into tray until pliers are submerged.

Note: If pliers are equipped with cushion grips, only the head should be immersed.

Figure 1



☐ 4. Open and close pliers several times while submerged.

☐ 5. Let pliers sit in solvent for 2 or 3 minutes.

☐ 6. Remove pliers from solvent.

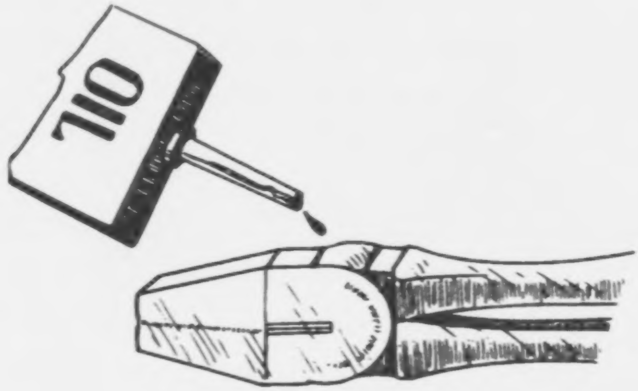
☐ 7. Open and close rapidly until pliers work freely.

Note: If pliers will not yet work, repeat steps 1-5.

☐ 8. Wipe residue from plier joints with cloth.

☐ 9. Apply a couple of drops of oil to joints, and work until oil has penetrated.

Figure 2



☐ 10. Wipe excess oil from pliers.

Note: Have instructor check tool.

☐ 11. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ____________________

____

____

Objective 11

Job Sheet 2—Use a Cutting/Crimping Tool

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Cutting/crimping tool
- Solid insulated conductor—12 to 18 gauge
- Bolt—Size 6-32, 8-32, or 10-24, 10-32, 4-40
- Wire-lug—Same size as conductor
- Safety glasses

Procedure

☐ 1. Examine cutting/crimping tool.

☐ 2. Located stripping area of the cutting/crimping tool.

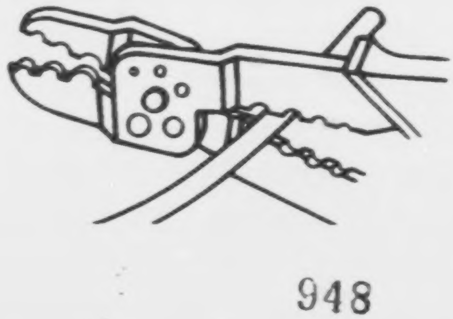
☐ 3. Locate correct-sized stripping slot for conductor.

Examples: AWG-18, AWG-20 wire size

☐ 4. Put on safety glasses

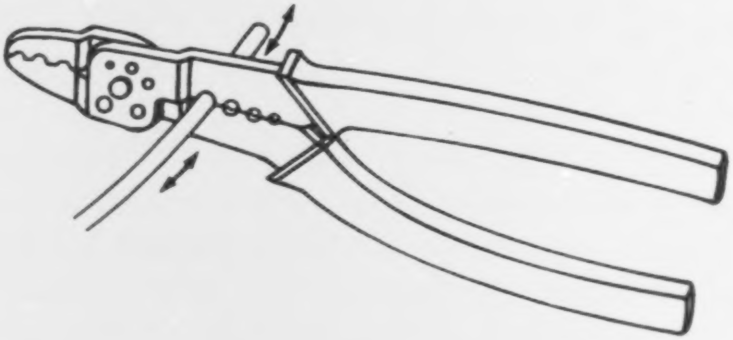
☐ 5. Open cutting/crimping tool and insert conductor into curved area of stripping slot leaving approximately 1/4 inch of conductor end extending from tool.

Figure 1



☐ 6. Slowly close cutting area by squeezing handles together.

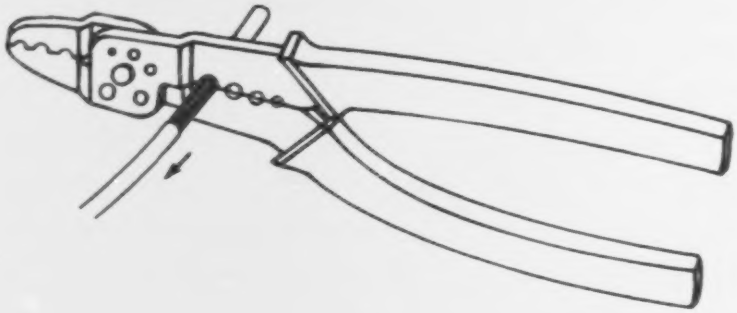
Figure 2



☐ 7. Pull conductor long lead away from cutting/crimping tool

Note: If the correct stripping slot was chosen, insulation should easily slide from the conductor. Have the instructor check your work.

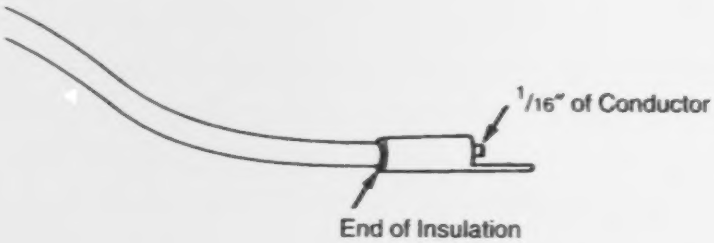
Figure 3



☐ 8. Put the wire lug on the conductor.

Note: The insulation should just touch the wire lug, and the bare conductor should protrude past the wire lug approximately 1/16 inch.

Figure 4

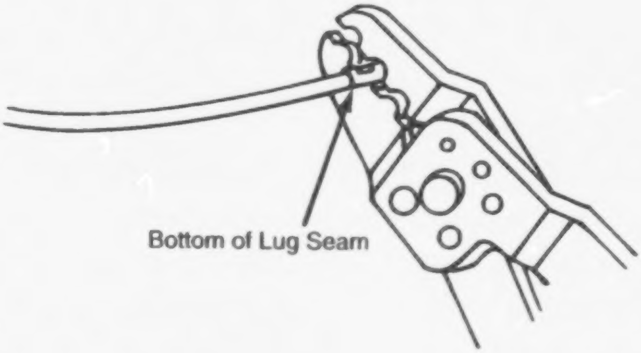


☐ 9. Locate the correct crimping area for size wire lug being used.

Note: The wire gauge number, the lug number, and the crimping tool number should all be the same.

☐ 10. Insert wire lug into crimping tool, making sure lug seam is on indenting side of crimping slot.

Figure 5



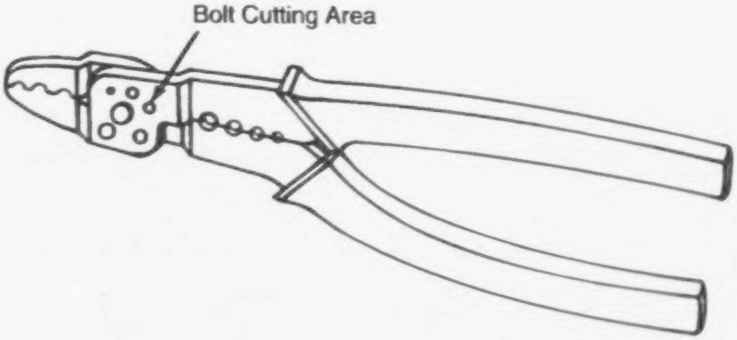
☐ 11. Squeeze the handles together to crimp the wire lug onto the conductor.

☐ 12. Remove the cutting/crimping tool.

Note: Have instructor check your work.

☐ 13. Locate the bolt cutting area of cutting/crimping tool.

Figure 6



☐ 14. Locate the correct cutting slot for the bolt.

☐ 15. Screw the bolt into the cutting hole from the screw (threaded) side of the tool.

Note: On the cutting/crimping tool, one side is threaded and the other side is unthreaded.

☐ 16. Screw the bolt into the cutting/crimping tool until the desired length is at centerpoint of cutting tool.

☐ 17. Squeeze the tool handles together until the bolt is cut.

Caution: When the bolt is cut, the unattached end may fly from cutter.

☐ 18. Remove the bolt from the cutting/crimping tool.

Note: Have the instructor check your work.

☐ 19. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 12

Job Sheet 3—Adjust Wire Strippers

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

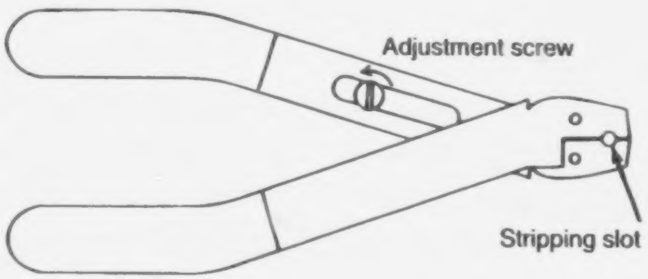
- Adjustable wire strippers
- Screwdriver or nut driver to fit adjustment screw
- Solid insulation conductor—12 or 14 gauge

Note: Strippers should be adjusted for stripping the most commonly used conductor in your area.

Procedure

☐ 1. Loosen the adjustment screw.

Figure 1



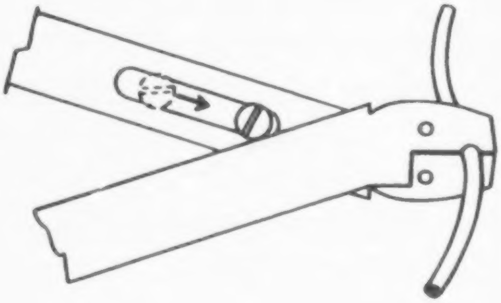
☐ 2. Insert the conductor into the stripping slot.

☐ 3. Close the stripper jaws until you feel that you have reached the conductor.

☐ 4. Open the jaws slightly.

☐ 5. Slide adjustment screw down to its resting position.

Figure 2

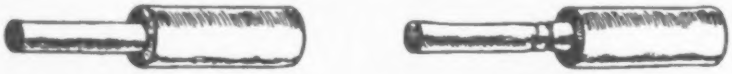


☐ 6. Strip off a fresh piece of insulation

☐ 7. Check the conductor for ring or nick damage.

Note: If nick occurs, loosen adjustment screw, move it back slightly, retighten, and test again until insulation is cut without conductor damage. Have instructor check your work.

Figure 3



Correctly Adjusted

Incorrectly Adjusted

☐ 8. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 13

Job Sheet 4—Set Up and Use a Hacksaw to Cut Conduit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Needle-nose pliers
- Pipe or conduit
- Safety glasses
- Hacksaw frame
- Hacksaw blade

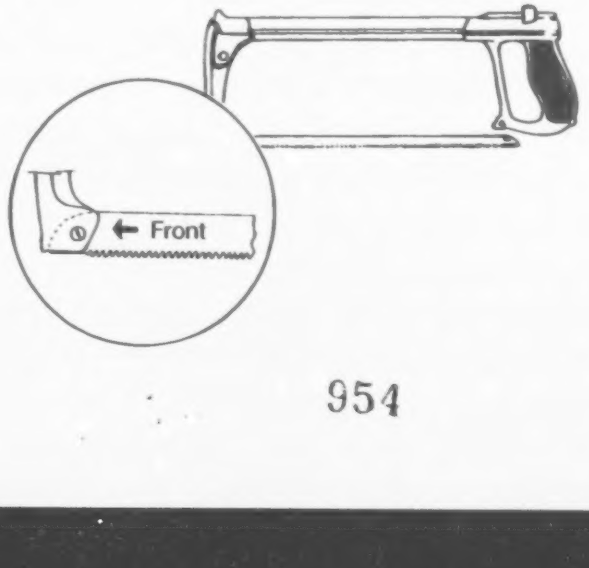
Note: A 24- or 32-tooth/inch blade is recommended for cutting pipe or conduit.

Procedure

☐ 1. Put on safety glasses and gather tools and equipment.

☐ 2. Insert blade in frame, ensuring that tooth angles are pointed toward front of saw. See insert in Figure 1.

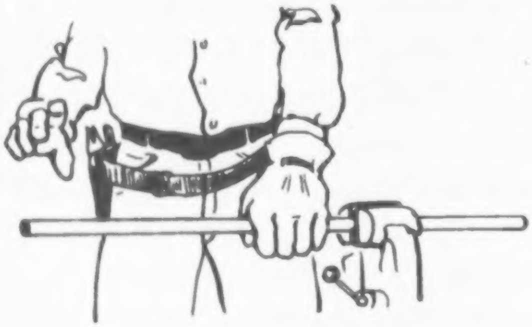
Figure 1



☐ 3. Secure pipe or conduit for cutting.

Note: Short pieces of pipe are easier to cut in a vise.

Figure 2



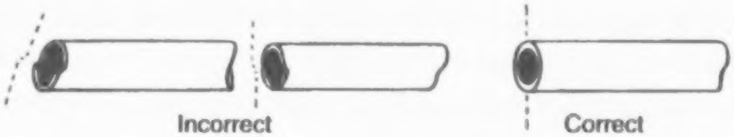
☐ 4. Rest the hacksaw blade perpendicular to the pipe or conduit at cutting point.

☐ 5. Push *forward* gently until cut is started, taking care not to exert extra pressure on saw.

☐ 6. Make reciprocal strokes until cut is finished.

Note: Excessive speed while cutting can ruin blades. Do not use over thirty full strokes per minute. Your cut should be straight and relatively smooth.

Figure 3



Note: Have the instructor check your cut.

☐ 7. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ________________________________

____

____

Objective 14

Job Sheet 5—Ream and Thread Rigid Conduit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria. These tasks shall be completed using non-electrically powered tools.

Tools, Equipment, and Materials

- Pipe vise/stand
- Piece of rigid conduit
- Safety glasses
- Hand reamer
- Oiler and thread cutting oil
- Die and die stock
- Gloves

Note: You will need a ratchet handle or brace depending on which type reamer is used.

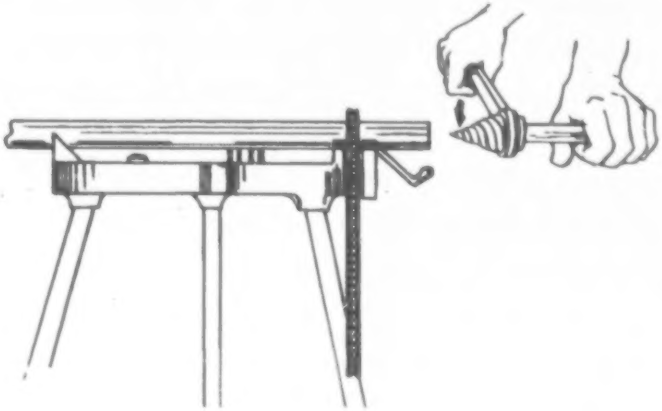
Procedure

> **Caution:** Be safety conscious around cut pieces of rigid conduit. Sharp ridges or spurs can cause deep cuts.

☐ 1. Place conduit in vise

☐ 2. Insert reamer tip in conduit

Figure 1

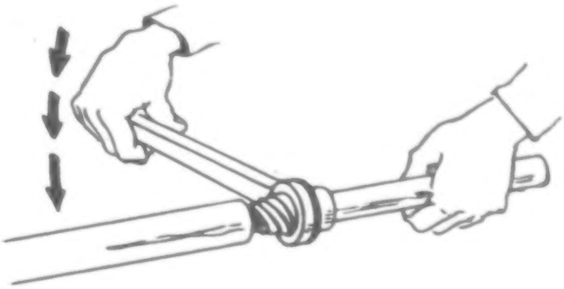


☐ 3. Apply light forward pressure to push reamer into conduit.

☐ 4. Start rotating reamer in clockwise direction.

Note: Reamer should bite instantly if proper pressure is applied. Reamer can be damaged if rotated in the wrong direction.

Figure 2

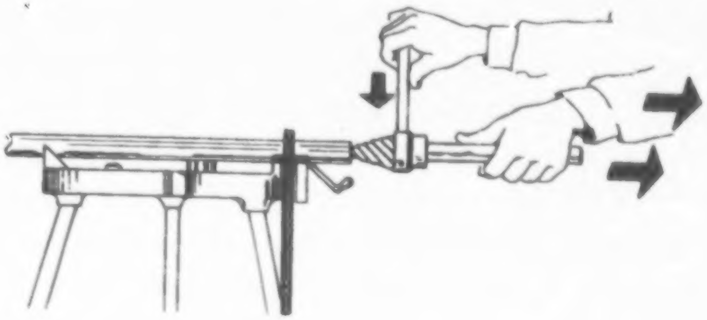


☐ 5. Rotate reamer until burrs are removed.

Note: This is a developed skill; the reamer can be pulled out and your progress inspected.

☐ 6. Pull reamer back while continuing to rotate to prevent reamer from leaving a burr

Figure 3



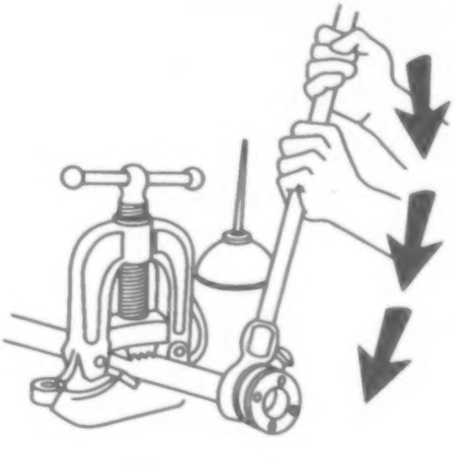
☐ 7. Place die in die stock and secure.

☐ 8. Place die on pipe.

☐ 9. Start die straight on pipe.

☐ 10. Press evenly and turn the die.

Figure 4



☐ 11. Apply cutting oil while turning the die.

Note: Place a container under pipe vise to catch dripping oil.

☐ 12. Continue this procedure until the desired amount of threads have been cut.

☐ 13. Remove die by turning counter clockwise.

Note: Hold onto the die stock firmly while removing it so you won't drop it when it comes to the end of the threads.

☐ 14. Clean threads with a brush.

Caution: Do not use compressed air for cleaning.

☐ 15. Have instructor inspect your work.

☐ 16. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 15

Job Sheet 6—Bend EMT Conduit

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: Because of the difference in bender shoe markings, the height of this bend and its determination will be left to the instructor.

Tools, Equipment, and Materials

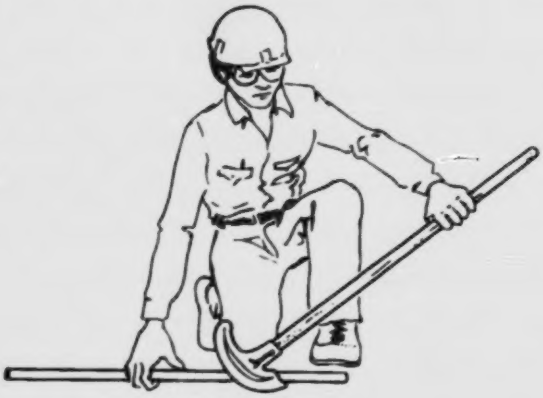
- $^{1}/_{2}$-inch EMT bender
- $^{1}/_{2}$-inch EMT (length optional)
- Safety glasses
- Gloves

Procedure

☐ 1. Put on safety glasses and gloves, and gather tools and equipment.

☐ 2. Place conduit in bender jaw.

Figure 1

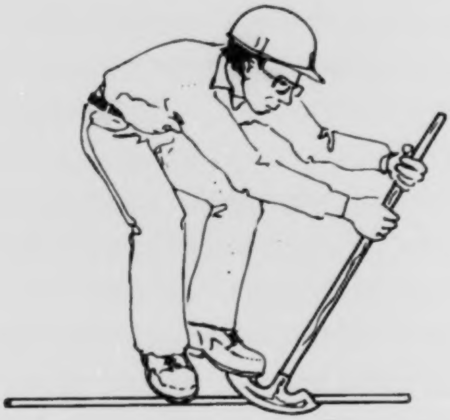


☐ 3. Apply light pressure on handle to hold conduit in place.

☐ 4. Place one foot on bender kick pad.

☐ 5. Place other foot on conduit.

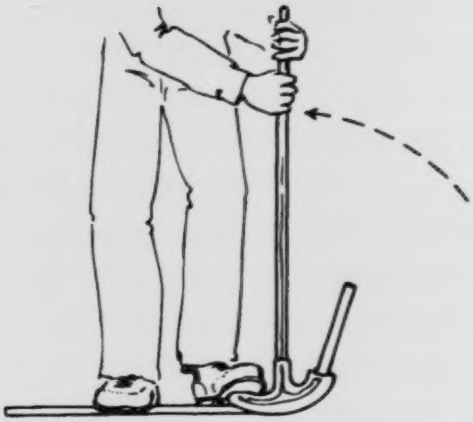
Figure 2



☐ 6. Apply heavy pressure on bender kick pad while pulling handle to a straight up position.

Note: If pressure is not applied solidly to kick pad, conduit can wrinkle or collapse.

Figure 3

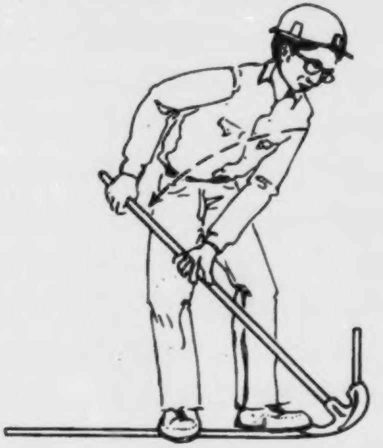


☐ 7. Reposition feet for comfort.

☐ 8. Reapply kick pad and bender handle pressure until bend is completed.

Note: A square can be used to evaluate your accuracy until you develop your skills. Have your instructor check your work.

Figure 4



☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ____

____

____

Objective 17

Job Sheet 7—Use a Knockout Punch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Center punch
- Ball peen hammer
- 10-inch adjustable wrench or 1/2-inch ratchet with socket drive to fit nut
- Appropriate extension cord
- Safety glasses
- Gloves
- Drill motor
- Metal drill large enough to let the knockout punch bolt through the opening it makes
- Metal to be punched

  Note: Most punches are rated up to 10-gauge metal

- Vise

  Note: A vise is needed when the material to be cut is not fastened to a wall or is too small to anchor by standing on it.

Procedure

☐ 1. Put on safety glasses and gloves, and gather materials and equipment.

☐ 2. Make an indentation in the center of the are you are going to punch.

☐ 3. Secure the drill in the drill motor, and attach motor to power source.

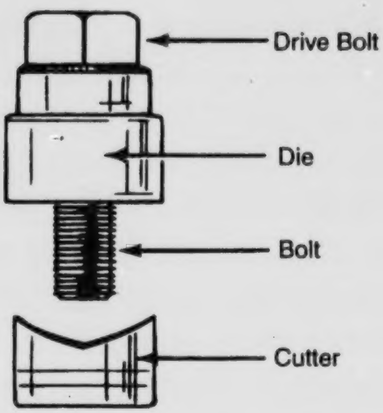
☐ 4. Place the drill tip perpendicular to the work and in the indentation you made with the center punch.

☐ 5. Holding the drill motor firmly, turn it on and drill a hole slightly larger than the KO punch bolt.

> **Caution:** Hold the drill motor while drilling. A loose grip can cause an accident. Remember that the drill will be hot; use caution until it cools.

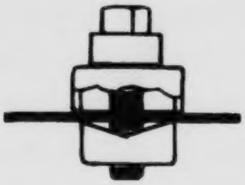
☐ 6. Separate the knockout punch cutter from the die and bolt.

Figure 1



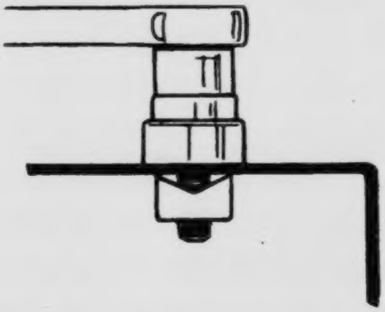
☐ 7. Insert the bolt through the drilled hole and put the cutter back on the screw.

Figure 2



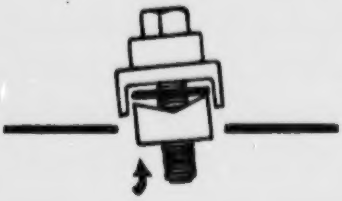
☐ 8. Tighten the drive bolt with wrench or socket.

Figure 3



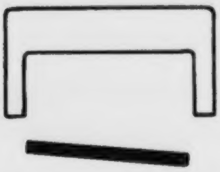
☐ 9. When the cutter is finally pulled through, remove the knockout punch.

Figure 4



☐ 10. Remove the cutter from the bolt and shake out the punched metal.

Figure 5



☐ 11. Lubricate cutter, if needed, and replace.

Note: Have instructor check your work.

☐ 12. Clean work are, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 18

Job Sheet 8—Use a Hole Saw

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Hole saw and arbor (size determined by instructor)
- Drill motor
- Center punch
- Safety glasses
- Safety gloves
- Hammer
- Metal to be cut

Note: Most hole saws can drill through any machinable material up to 1 1/8 inches thick.

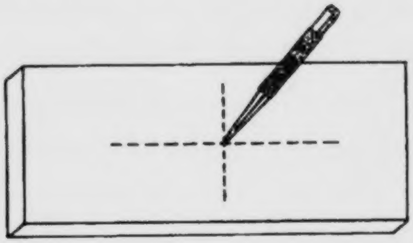
Procedure

☐ 1. Put on safety glasses and gloves.

☐ 2. Locate point on metal where hole is to be cut.

☐ 3. Place center punch on center point of hole to be cut.

Figure 1



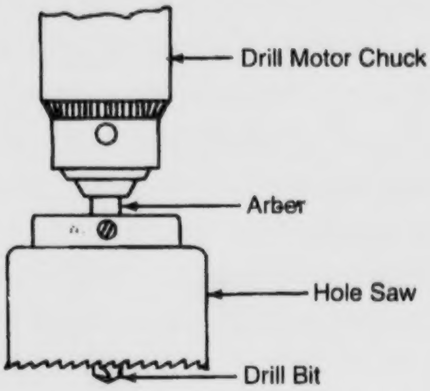
☐ 4. Strike center punch with hammer.

Note: How hard the center punch is struck is determined by the type and thickness of the metal being used. If struck too hard, softer, thinner metal will bend easily.

☐ 5. Insert hole saw arbor into the drill motor chuck.

Caution: Be sure chuck is tight, and chuck key is removed before drilling.

Figure 2



☐ 6. Attach drill motor to power source.

☐ 7. Place tip of drill in hole made by the center punch.

Note: If material is to be cut is not fastened solidly, put material in vise before cutting.

Caution: While drilling, hold the drill motor firmly with both hands. The hole saw can become jammed causing the drill motor to spin.

☐ 8. Turn on drill motor until hole saw has cut completely through metal being cut; use cutting oil on heavy metal.

Note: Have instructor check your work.

☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________

____

____

Objective 28

Assignment Sheet 1—Determine Dimensions on a Drawing Using an Architects Scale

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Directions are followed	______
• Dimensions are accurate	______
• Assignment is neat and completed on time	______

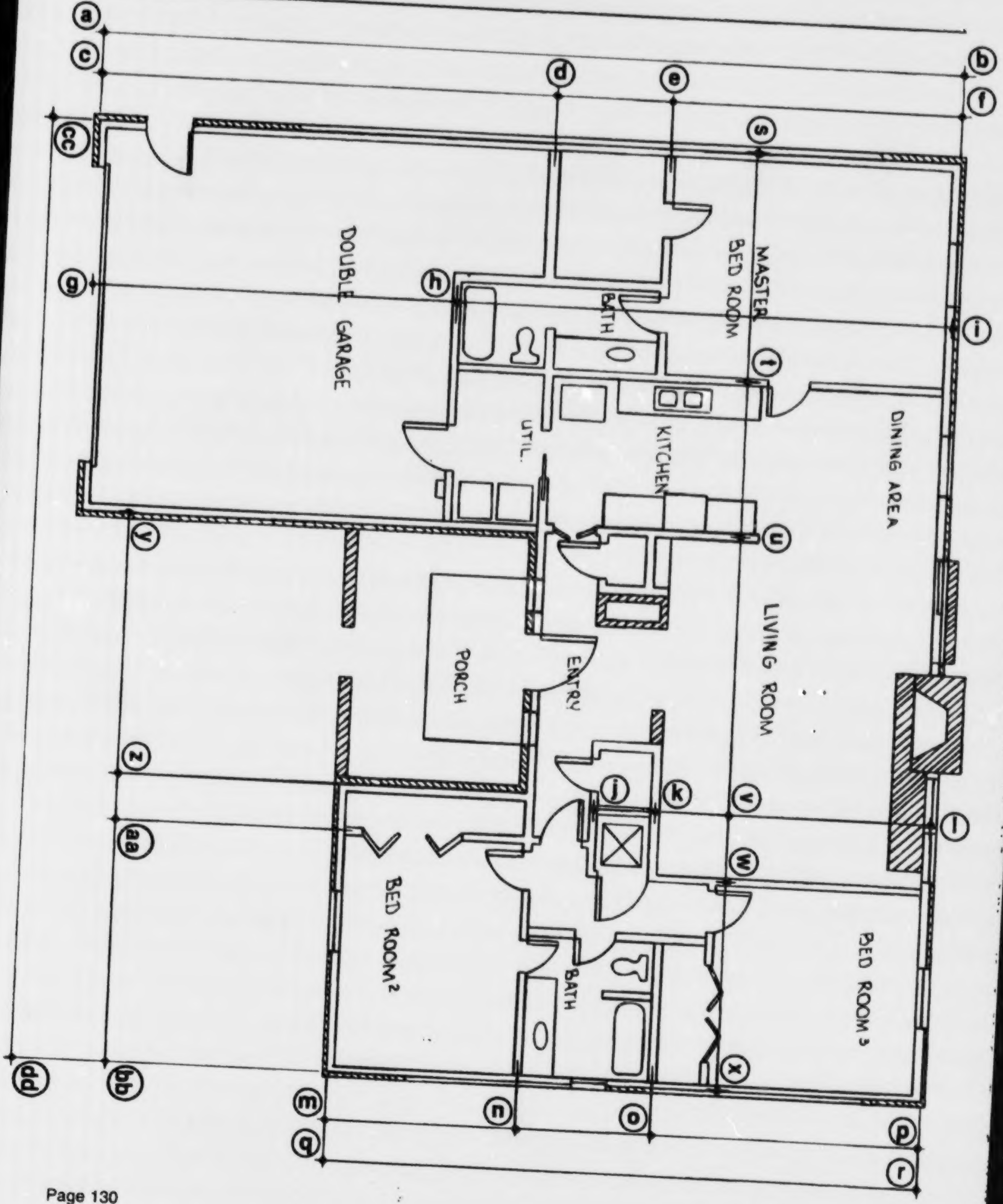
Basic Skills

Reading Mathematics Employability

Directions

Use the architect's scale at $^1/_8'' = 1'$ to determine the dimensions on the drawing on the next page. As you are working, write your answers on the dimension lines of the drawing. Check all answers and then transfer your answers to the blanks provided on the following page.

Assignment Sheet 1


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v
w
x
y
z
aa
bb
cc
dd
DOUBLE GARAGE
MASTER BED ROOM
BATH
UTIL.
KITCHEN
DINING AREA
LIVING ROOM
PORCH
ENTRY
BED ROOM²
BATH
BED ROOM³

Assignment Sheet 1

Answer blanks for dimensions.

1. a–b= ____________________

2. c–d= ____________________

3. d–e= ____________________

4. e–f= ____________________

5. g–h= ____________________

6. h–i= ____________________

7. j–k= ____________________

8. k–l= ____________________

9. m–n= ____________________

10. n–o= ____________________

11. o–p= ____________________

12. q–r= ____________________

13. s–t= ____________________

14. t–u= ____________________

15. u–v= ____________________

16. v–w= ____________________

17. w–x= ____________________

18. y–z= ____________________

19. z–aa= ____________________

20 aa–bb= ____________________

21. cc–dd= ____________________

22. What is the distance from the east wall to the middle of the kitchen sink?

____

23. What is the distance from the north wall to the north edge of the kitchen sink?

____

Objective 29

Job Sheet 1—Use a Hydraulic Knockout Punch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

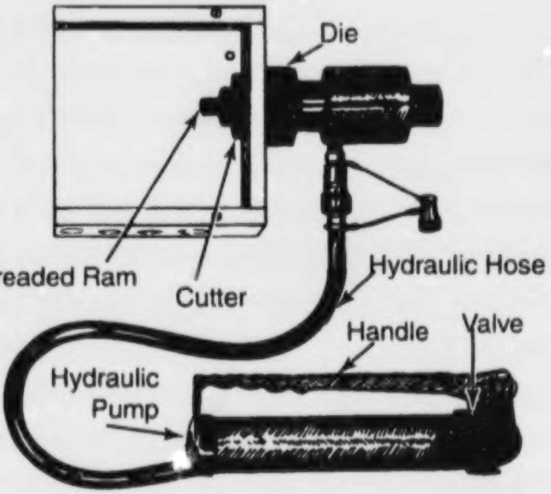
Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Hydraulic knockout punch with hand pump

Figure1



- Instructions for knockout punch
- Drill motor
- Metal drill bit large enough to accept the knockout punch bolt
- Vise, if metal to be cut is not fastened to a wall, or if metal is too small to hold
- Eye protection

- Heavy-duty extension cord
- Center punch
- Gloves
- Metal to be punched

Note: Most punches are rated up to 10-gauge metal

Procedure

☐ 1. Read instructions for hydraulic knockout set.

☐ 2. Assemble hydraulic knockout set, referring to instructions and to Figure 1.

☐ 3. Put on eye protection.

☐ 4. Fasten metal to be punched in vise if necessary.

☐ 5. Put on gloves.

☐ 6. Use center punch to make an indentation in the center of the space to be knocked out.

☐ 7. Place drill bit on indentation made with center punch, and drill a hole slightly larger than the knockout punch bolt.

> **Caution:** Hold the drill firmly while drilling. A loose grip could cause an accident. Remember that the drill will be hot. Use caution until it cools.

☐ 8. Separate knockout punch cutter from die and threaded ram.

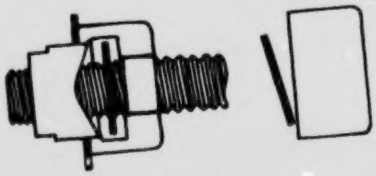
☐ 9. Insert threaded ram through drilled hole; replace cutter on threaded ram.

☐ 10. Close hydraulic valve; pump handle until cutter pulls through metal.

Note: After cutter is pulled through, the knockout punch is easily removed.

☐ 11. Open the valve and remove cutter from threaded ram; shake out punched metal.

Figure 2



Slug falls free in die. Tip die to remove slug.

☐ 12. Replace cutter on ram, making sure that it is properly lubricated.

Note: Have the instructor evaluate your work.

☐ 13. Clean work area, and put away equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 30

Job Sheet 2—Bend a 90-Degree Stub Using a Hydraulic Pipe Bender

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Hydraluc pipe bender
- 5 feet of 1-inch rigid galvanized conduit
- Tape
- Marking pencil

Procedure

Note: The procedure that follows is specifically for a Greenlee #880 bender. Other benders may vary slightly in measurements, but the procedure will be basically the same.

☐ 1. Assemble hydraulic bender using a 1-inch shoe and pipe supports.

☐ 2. Check chart on bender for minimum stub length, required deduction for stub, and ram travel measurements. Record data.

- Minimum stub length = ____________________
- Stub deduction = ____________________
- Ram travel = ____________________

☐ 3. Mark stub length (24 inches) on pipe.

☐ 4. Subtract stub deduction measurement from 24-inch mark, and make a second mark at that point.

☐ 5. Place pipe in bender shoe, matching center mark of shoe with second mark on pipe.

☐ 6. Close hydraulic pump valve, and pump handle until ram travel gauge indicates amount of travel for a 1-inch pipe with a 90-degree bend.

☐ 7. Release hydraulic pump valve, and allow ram to return fully before removing pipe.

☐ 8. Check height of stub and accuracy of 90-degree bend.

Note: Show work to instructor for evaluation.

☐ 9. Disassemble bender, clean work area, and return equipment and materials to their proper places.

Evaluator's Comments: ______________________________

____

____

Objective 31

Job Sheet 3—Make Offset and 90-Degree Bends Using an Electric PVC Heater

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- PVC conduit
  Note: Check *Code* reference on minimum radius for PVC
- PVC cutter
- Electric PVC heater
- Instructions for PVC heater
- Small pail of water
- Shop rag or sponge
- Piece of board at least 1 inch thick and as wide as desired offset
- Nails to tack up piece of board
- Eye protection
- Gloves
- Pipe vise

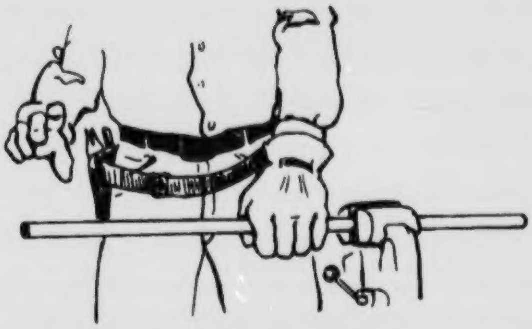
Procedure

Procedure for heating conduit and making a 90-degree bend

☐ 1. Put on eye protection and gloves.

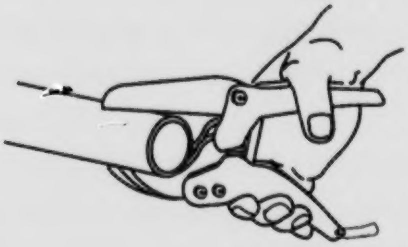
☐ 2. Secure piece of PVC in vise for cutting.

Figure 1



☐ 3. Pick up PVC cutter and align the single blade on the marked cutting point, ensuring the pipe is in the throat of the cutter (underside).

Figure 2



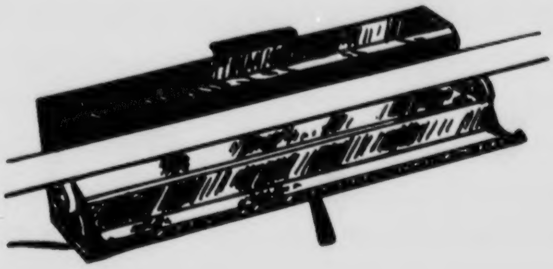
☐ 4. Squeeze the handles together firmly until the cut is finished.

☐ 5. Read instructions for PVC heater.

☐ 6. Plug in PVC heater and turn on; allow unit to preheat for 15 minutes in closed position.

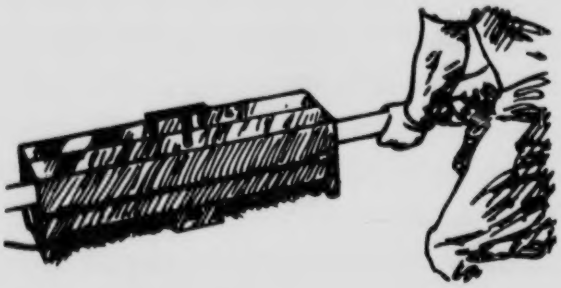
☐ 7. Open unit and insert PVC as shown in Figure 3

Figure 3



☐ 8. Close unit, and rotate PVC for 1 to 2 minutes or until it becomes pliable enough for bending.

Figure 4



☐ 9. Remove PVC from heating chamber when it becomes soft and is easily bent.

Caution: Conduit will be very hot. Handle it carefully to avoid burns.

Note: Experience will help in determining when PVC is pliable for bending. Make sure that conduit is adequately heated. Larger pieces of conduit tend to kink unless adequately heated.

☐ 10. Turn off PVC heater.

☐ 11. Form the 90-degree bend by hand on a flat surface.

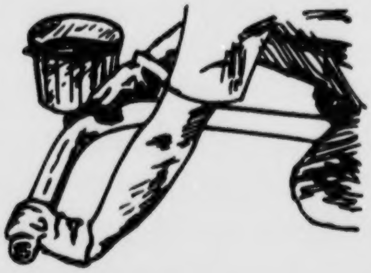
Note: Another method of forming the 90-degree bend is to push the conduit into a corner of the room, leaving the desired amount of straight conduit on each side of the bend.

☐ 12. Apply water-soaked rag or sponge to PVC to set the bend.

Caution: Do not use water next to the electric heater because of shock hazard.

Note: If bend is made in the corner of the room, an alternate method of setting the bend is to use straight boards to hold the conduit against the wall until it cools and hardens.

Figure 5



Procedure

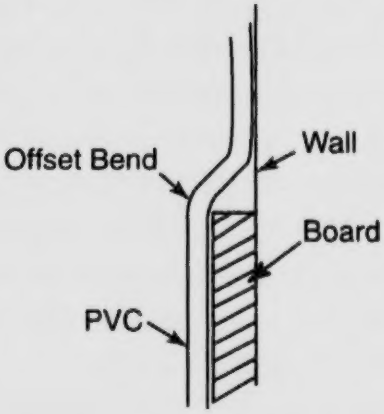
Procedure for heating conduit and making an offset bend

☐ 1. Determine amount of offset desired.

☐ 2. Turn on PVC heater and allow it to preheat for 15 minutes in closed position.

☐ 3. Nail prepared piece of board to wall so that PVC may be shaped by placing it against the wall and then bending it away from the wall to lie parallel to outer edge of board as shown in Figure 6.

Figure 6



☐ 4. Open PVC heater, and insert PVC.

☐ 5. Close unit, and rotate PVC for one to two minutes or until it becomes pliable enough for bending.

☐ 6. Remove PVC from heating chamber when it becomes soft and is easily bent.

Caution: Conduit will be very hot. Handle it carefully to avoid burns.

☐ 7. Turn off PVC heater.

☐ 8. Lay conduit against wall and against board as shown in Figure 6, holding the ends against the board and the wall until PVC cools and hardens.

Note: Show work to instructor for evaluation and comment.

☐ 9. De-energize PVC heater.

☐ 10. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 32

Job Sheet 4—Cut, Ream, and Thread Rigid Conduit with a Power Threader

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Power threader
- Stand for power threader
- Hacksaw
- Pipe reamer accessory
- Adjustable die head accessory
- Tool carriage accessory
- Carriage lever accessory
- Instructions for power threader and accessories
- Oiler and thread-cutting oil
- Clean cloth
- Eye protection
- Gloves
- Length of steel pipe

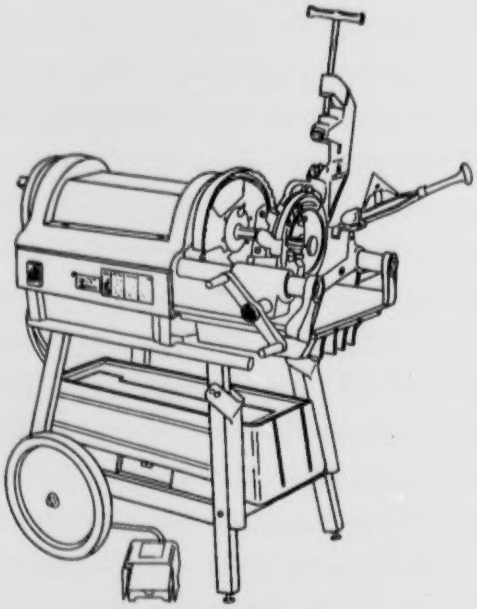
Procedure

☐ 1. Read instructions for power threader and accessories.

☐ 2. Install power threader on stand.

☐ 3. Install pipe reamer, adjustable die head, tool carriage, and carriage lever on power threader.

Figure 1



☐ 4. Put on eye protection and gloves.

☐ 5. Insert pipe into power threader, allowing pipe to extend far enough to clear chuck; tighten chuck jaws and rear centering device.

☐ 6. Mark pipe at point where cut is to be made, and then cut with hacksaw.

☐ 7. Place reamer in pipe end, allowing reamer handle to rest against tool support bar.

☐ 8. Turn on motor.

☐ 9. Press reamer into pipe to remove burrs.

☐ 10. Turn off motor and lay reamer against tool rest.

☐ 11. Place threader die head on pipe.

☐ 12. Cut required number of threads, keeping oil on die stock until threads are cut.

☐ 13. Turn off motor.

> **Caution:** Always allow machine to come to a complete stop before reversing direction.

☐ 14. Turn on motor, turn power drive switch to "reverse," and remove threader from pipe.

☐ 15. De-energize power threader.

Note: Show threaded pipe to instructor for evaluation and comments.

☐ 16. Dismantle equipment, clean work area, and put away all materials and equipment.

Evaluator's Comments: ______________________________

____

____

Objective 33

Job Sheet 5—Measure Resistance Using a VOM

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Multimeter with test leads
- Various resistors wrapped in masking tape to conceal their values, and numbered for reference

Procedure

Caution: Never check resistance on a live circuit. It can severly damage the equipment.

☐ 1. Position meter to correct function position.

☐ 2. Position meter range switch to one of the resistance scales.

☐ 3. Insert meter leads in correct meter jacks, observing polarity.

☐ 4. Connect meter across component to be checked.

☐ 5. Determine correct meter position closest to center scale or toward zero.

☐ 6. Remove leads from component and touch (short) leads together while using "Ohm's Zero Adjust" to position needle to the zero position.

☐ 7. Reconnect meter to component.

☐ 8. Read meter for Ohmic value.

Note: Be sure to use proper scale, reading from right to left.

☐ 9. Turn off meter.

☐ 10. Record your readings below:

- Resistor #1 ____________________
- Resistor #2 ____________________
- Resistor #3 ____________________
- Resistor #4 ____________________
- Resistor #5 ____________________

Note: Show your results to the instructor.

Evaluator's Comments: ____________________

____

____

Objective 34

Job Sheet 6—Measure DC Voltages Using a VOM

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- VOM with test leads
- DC power source (power supply or battery)

Procedure

☐ 1. Position meter to correct function.

Examples: –DC, +DC, or AC

☐ 2. Observing polarity, connect meter leads to meter.

☐ 3. Determine correct range scale.

Note: Use highest range if voltage is unknown.

☐ 4. Turn on power supply.

☐ 5. Adjust output to any voltage less than 50 volts.

☐ 6. Observing polarity, connect meter leads to circuit to be tested.

Note: Always hook VOM across the components or power source to be tested. If the indicator needle moves to the left, the lead polarity is wrong.

☐ 7. Record results below:

- DC source = ______________________________
- Voltage reading = ______________________________

☐ 8. Change the source voltage or measure a second battery.

- DC source = ______________________________
- Voltage reading = ______________________________

Note: Show your results to the instructor.

Evaluator's Comments: ______________________________

____

____

Objective 35

Job Sheet 7—Measure AC Voltages Using a VOM

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- VOM with test leads
- Alternating current power source

Example: Duplex receptacle

Procedure

☐ 1. Position meter to correct function.

Examples: –DC, +DC, or AC

☐ 2. Observing polarity, connect meter leads to meter.

☐ 3. Determine correct range scale.

Note: Use highest range if voltage is unknown.

☐ 4. Connect meter leads to circuit to be tested.

Note: Lead polarity is not important when measuring AC voltages because polarity changes at a rate of 60 cycles per second (USA).

☐ 5. Measure "line voltage" of power receptacle. See Figure 1.

> **Caution:** 120 Volts can cause injury or death. DO NOT touch the metal parts of the test leads while measuring.

☐ 6. Set meter on lowest scale at which it will register.

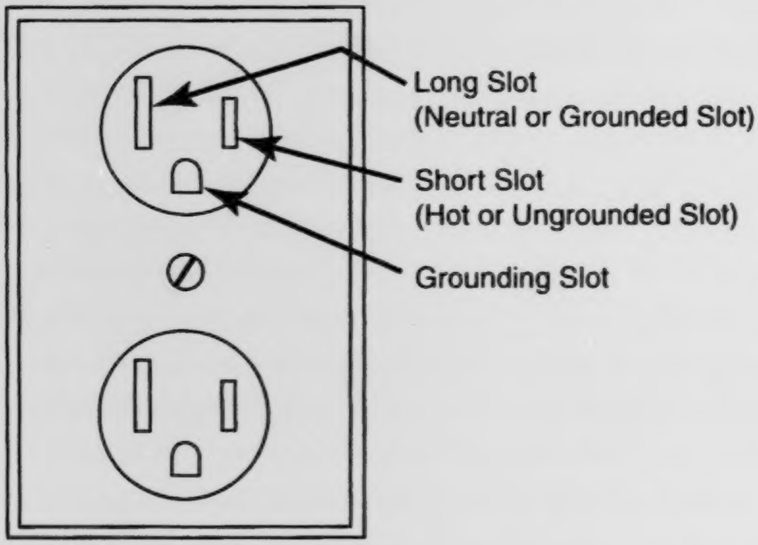
☐ 7. Record readings below:

- Voltage between slotted jacks = ____________________
- Voltage between short slot and grounding slot = __________
- Voltage between long slot and ground slot = __________

☐ 8. Disconnect meter leads.

☐ 9. Turn off meter.

Figure 1


Long Slot
(Neutral or Grounded Slot)
Short Slot
(Hot or Ungrounded Slot)
Grounding Slot

Part 2

Three-Phase Power Source

Tools, equipment, and materials

- VOM with test leads
- Source of three-phase AC power such as a fused disconnect
- Safety glasses

Procedure

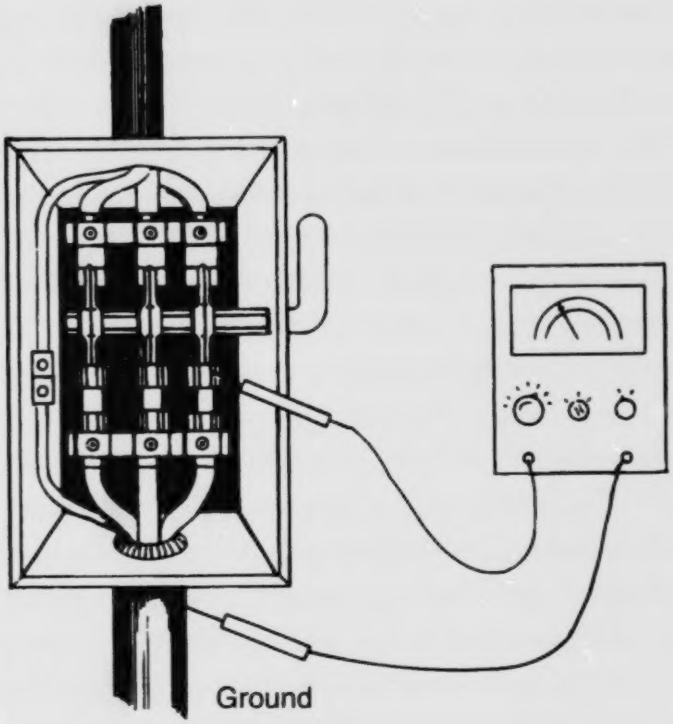
Note: The instructor must supervise each student.

☐ 1. Set multimeter for AC voltage measurement.

Note: Be sure setting is correct.

☐ 2. With instructor watching, carefully measure between each of the three terminals at the top of the disconnect and a ground terminal; record your measurements.

Figure 2



Voltages from terminals to ground

- ______________________________
- ______________________________
- ______________________________

☐ 3. Measure between first and second, first and third, and second and third terminals; record the readings below:

- 1 to 2 = ______________________________
- 1 to 3 = ______________________________
- 2 to 3 = ______________________________

Note: Show your measurements to your instructor.

☐ 4. Disconnect meter leads.

☐ 5. Turn off meter.

☐ 6. Put equipment and materials away.

Evaluator's Comments: ______________________________

____

____

Objective 36

Job Sheet 8—Measure Amperage Using a Clamp-on Ammeter

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Clamp-on ammeter
- Source of three-phase AC power

Procedure

☐ 1. Position meter to highest scale.

☐ 2. Clamp the tongs around the live conductor.

> **Caution:** Use extreme care when clamping the tongs around the conductor. Remember live circuits can KILL or INJURE you.

Note: Place the tongs around only one conductor; failure to do so could result in inaccurate measurements.

☐ 3. Reposition the scale to the lowest readable scale.

☐ 4. Record measurements below:

- Line 1= ________________________________
- Line 2 = ________________________________
- Line 3= ________________________________

☐ 5. Put equipment and materials away.

Evaluator's Comments:

____

____

Objective 37

Job Sheet 9—Determine the Current of a Multiple Loop Using a Clamp-on Ammeter

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria **Rating**

- Gathered and used appropriate equipment and materials ______
- Performed procedure safely ______
- Performed all steps in procedure ______
- Performed steps in correct sequence ______
- Cleaned work area ______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Clamp-on ammeter
- AC power source with a load (see the instructor)

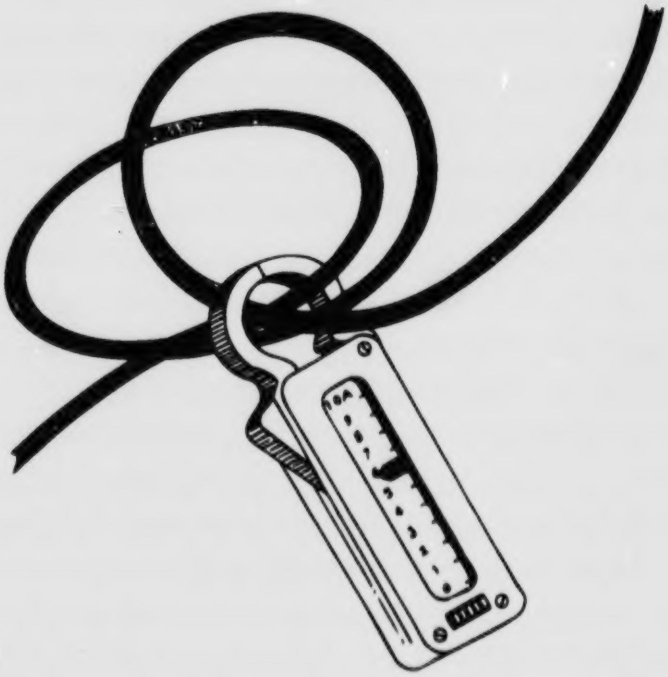
Procedure

☐ 1. Form three loops in one conductor feeding the load.

☐ 2. Tape the loops tightly together.

☐ 3. Clamp the tongs through the loops

Figure 1



☐ 4. Read the meter and record.

- Initial measurement = ______________________________

☐ 5. Divide reading by the number of loops (3) and record the actual current value.

- Actual current value = ______________________________

Note: Show your measurements to your instructor.

☐ 6. Put equipment and materials away.

Evaluator's Comments:

____

____

Objective 38

Job Sheet 10—Check Conductor Insulation with a Megger

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Megger
- 20-foot run of conduit with three #12 THHN conductors (one conductor should have a slight nick in the insulation approximately midway)
- Pouch tools

Procedure

☐ 1. Isolate each conductor. Be sure conductor ends do not touch each other or the conduit.

☐ 2. Clamp the red lead to the conduit.

☐ 3. Clamp the black lead to one of the conductors.

☐ 4. Record reading.

☐ 5. Repeat steps 3 and 4 with the other two conductors.

- Conductor 1 = ______________________________
- Conductor 2 = ______________________________
- Conductor 3 = ______________________________

☐ 6. From your readings, determine which conductor is bad.

Note: Show your results to the instructor.

☐ 7. Put equipment and materials away.

Evaluator's Comments:

Objective 8

Focus Assignment—Using the *National Electrical Code*

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______

Basic Skills

Reading Writing

Introduction

In this unit you will be studying the purpose and intent of the *NEC*, and will learn how to locate requirements for specific applications.

Directions

Obtain a copy of the *NEC* from your instructor and read Article 90-Introduction.

a. In your own words, explain the difference between mandatory and permissive rules.

____

____

____

____

____

b. Using the *NEC*, find an example of a:

1. Mandatory rule

Code Section: ________________ Rule: ________________

____

____

2. Permissive rule

Code Section: ________________ Rule: ________________

____

____

Objective 9

Assignment Sheet 1—Use the *National Electrical Code* (*NEC*) Index to Answer Questions About *Code* Sections

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• Eight of ten answers correct per answers to Assignment Sheet 1	______

Basic Skills

Reading

Directions

Use the *National Electrical Code* index to answer the following questions. Write the correct answers in the blanks.

a. What article covers aircraft hangers?

Article ______________________

b. What section covers equipment bonding jumpers?

Article ______________________

c. What section covers boxes over 600 volts?

Code section ______________________

d. What section covers support of busways?

Code section ______________________

e. What section covers luminaires (fixtures) in clothes closets?

Code section ______________________

f. What section covers the clearances of recessed luminaires (fixtures)?

Code section ______________________

g. What section covers overcurrent protection in panelboards?

Code section ______________________________

h. What section covers generator installations in recreational vehicles?

Code section ______________________________

i. What section covers construction specifications for rheostats?

Code section ______________________________

j. What section covers guarding and grounding on x-ray equipment?

Code section ______________________________

Objective 10

Assignment Sheet 2—Use the *National Electrical Code* (*NEC*) Title Page, Table of Contents, and Introduction to Answer Questions

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• All answers correct per answers to Assignment Sheet 2	______

Basic Skills

Reading

Directions

Complete the following statements about facts found in the *National Electrical Code* Table of Contents, Introduction, or on the Title Page. Indicate the code section number that applies to each statement (if applicable).

a. The purpose of this *Code* is the practical __________________ of persons and property from hazards arising from the use of electricity. *Code* Section ______________

b. The *Code* is divided into the introduction and ______________ chapters. *Code* Section ______________

c. Chapter ____________ contains tables. *Code* Section ______________

d. A ______________ line in the margin indicates that the material differs from the previous edition.

e. ______________ rules are those that identify actions that are specifically required or prohibited and are characterized by the use of the terms SHALL or SHALL NOT. *Code* Section ______________

f. Fine Print Notes (FPN) (explanatory material) are ______________ only and are not enforceable as requirements of this *Code*. *Code* Section ______________

Objective 11

Assignment Sheet 3—Use the *National Electrical Code* First Chapter to Define Terms

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• All answers correct per Answers to Assignment Sheet 3	______

Basic Skills

Reading Writing

Directions

Find the following information using the *National Electrical Code* first chapter.

a. Define the following terms. *Code* section ____________

1. Ampacity—____

____

____

2. Branch circuit—____

____

____

3. Outlet—____

____

____

4. Service Cable—____

____

____

Assignment Sheet 3

5. Bonding—____________________

6. Covered conductor—____________________

7. Receptacle—____________________

8. Service drop—____________________

9. Device—____________________

10. Disconnecting means—____________________

11. Equipment—____________________

12. Overload—____________________

13. Service lateral—____________________

14. Thermally protected—______________________________

____

____

15. Weatherproof—____________________________________

____

____

16. Ventilated—______________________________________

____

____

17. Solar photovoltaic system—__________________________

____

____

18. Service point—___________________________________

____

____

19. Readily accessible—_______________________________

____

____

20. Enclosed—_______________________________________

____

____

Objective 12

Assignment Sheet 4—Use the *National Electrical Code* to Answer General Questions Related to Residential Wiring Practices

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• All answers correct per Answers to Assignment Sheet 4	______

Basic Skills

Reading

Directions

Give article number and answer to each of the following questions.

Note: The problem solving steps listed below are taken from Objective 7 of the Information Sheet.

Example: Are ground-fault circuit-interrupters required on 125 volt single-phase 20-amp temporary construction receptacles?

Step 1: Refer to index: "Construction sites" is located and "ground-fault circuit-interrupter, protection for" is listed. Construction is the key word.

Step 2: Note listing of article (527).

Step 3: Find the page number for the article; turn to it (70-430).

Step 4: Find section number by turning pages in article 527.6(A) and (B).

Answer: From the article on branch circuits, 15-and 20-amp receptacles on temporary poles do require ground-fault circuit-interrupters; 527.6(A).

Problems

a. Do boxes made of metal need to be corrosion resistant?

Answer:______________________ Article No.__________

b. What is the definition of "approved?"

Answer:______________________ Article No.__________

c. Can a branch circuit used for lighting purposes and rated at 20 amps have a 12-amp dishwasher or other fixed appliance connected to it?

Answer:______________________ Article No.__________

Objective 13

Assignment Sheet 5—Use the *National Electrical Code* to Locate Allowable Ampacities for Various Conductors

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• 10 of 12 answers correct per Answers to Assignment Sheet 5	______

Basic Skills

Reading

Directions

List the various ampacities for the conductors as listed, using Tables 310.16 and 310.17. List the code section where applicable.

Example: List the ampacities for the following conductors when used in a 3 conductor cable with an ambient temperature of 100°F.

a. #12 TW copper ______________
b. #6 TW copper ______________

Answer: a. 20.5 (25 x .82) .82 is the correction factor for 100° cannot be fused over 20A
b. 45.1 (55 x .82) .82 is the correction factor for 100°

Note: The steps needed to answer #5 are not covered by the information pages. When you specify an ambient temperature that is anything other than 30°C (86°F), you arfe required to adjust ampacities by the "correction factors" under the charts on 310.16 and 310.17.

Problems

What is the allowable ampacity for the following single-insulated copper conductors used in free air if the ambient temperature is 90°F?

a. 14 TW ______________ *Code* Section ______________

b. 1 TW ______________

c. 1 THWN ______________

d. 10 THW ______________ *Code* Section ______________

Assignment Sheet 5

What is the allowable ampacity for the following aluminum conductors when used in a 3-wire cable, if the ambient temperature is 70°F?

e. 10 TW ______________ *Code* Section ______________

f. 12 TW ______________ *Code* Section ______________

g. I/O TW ______________

h. 6 TW ______________

Objective 14

Assignment Sheet 6—Use the *National Electrical Code* to Interpret Conduit Fill Tables

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• 14 of 15 answers correct per Answers to Assignment Sheet 6	______

Basic Skills

Reading Mathematics

Directions

List the maximum number of conductors allowed in the following conduits when all conductors are the same size. Use the *National Electrical Code*, Annex C to answer the following questions.

Note: For this assignment, conduit sizes and solutions to the example problem are stated in both the English and metric systems of measurement. Your instructor may require you to solve problem "e" using the metric system of measurement.

Problems

a. 1/2" (16) Conduit; Electrical Metallic Tubing *Code* Section __________
   1) 14 THHN __________
   2) 10 THWN __________
   3) 6 TW __________

b. 3/4" (21) Conduit; Flexible Metal Conduit *Code* Section __________
   1) 10 THWN __________
   2) 4 THWN __________

c. 1" (27) Conduit; Rigid Metal Conduit *Code* Section __________
   1) 6 TW __________
   2) 3 TW __________
   3) 6 THWN __________

d. 2" (53) Conduit; Intermediate Metal *Code* Section __________
   1) 4/0 THWN __________
   2) 4/0 TW __________

Assignment Sheet 6

Directions

Size conduit for combination conductors. Use the *National Electrical Code* Chapter 9, tables 4 and 5 to answer the following questions.

Example: Find the size of Rigid Metal Conduit required for three #4/0 and one #2/0 THW copper conductors supplying a panel board feeding combination loads.

- Enter chapter 9, table 5 and locate THW under the column marked "Type."
- Read down and locate 2/0 in the column marked "Size," staying within the THW column.
- Go across to the column marked "Approximate Area" and read .2624 in^2 (169.3mm^2)
- Now read down and locate 4/0 in the column marked "Size," staying within the THW area.
- Go across to the column marked "Approximate Area" and read .3718 (239.9)

  English calculation:

  3 (number of conductors) X .3718 = 1.1154
  1 (number of conductors) X .2624 = +.2624
  1.3778 sq. inches
  (minimum required diameter)

  Metric calculation:

  3 (number of conductors) x 239.9 = 719.7
  1 (number of conductors) x 169.3 = 169.3
  889.0 sq. millimeters
  (minimum required diameter)

- Enter Table 4 (Rigid Metal Conduit) and locate the column marked "Over 2 wires" since there are a total of 4 wires in the example problem.
- Read down the column until you find a number that is less than the required number of square inches or square millimeters you determined in your calculation from Table 5 (1.3778 in.^{2} or 889 mm.^{2}).
- 1.363 (square inches) or 879 (square millimeters) is just slightly smaller than the required, so you must go to the next higher figure of 1.946 (sq. inches) or 1255 (sq. millimeters), which is larger than the required.
- Read across to the left from 1.946 or 889 and read the required diameter of 2 1/2" (trade size) or 63 (metric size).

Answer: For the example problem you must use a minimum of 2 1/2" (trade size) or #63 (metric size) diameter rigid metal conduit.

1009

Problem

d. Find the size of Electrical Metallic Tubing required for two #3 and one #6 THHN copper conductors supplying a panel board feeding combination loads. Show your work in the space provided.

Objective 15

Assignment Sheet 7—Find Information in the *NEC*

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• Part 1—Thirteen of fifteen answers correct per Answers to Assignment Sheet 7	______
• Part 2—Eight of ten answers correct per Answers to Assignment Sheet 7	______
• Part 3—Seven of nine answers correct per Answers to Assignment Sheet 7	______
• Part 4—Seven of nine answers correct per Answers to Assignment Sheet 7	______

Basic Skills

Reading Writing

Directions Part 1

Use the *National Electrical Code*, Article 250, to find the following information. Write the correct answers in the appropriate blanks.

a. Article 250 covers general and specific requirements for grounding and bonding of electrical installations.

List the six specific requirements detailed in the *Code*.

1. ______________________________________

____

2. ______________________________________

____

3. ______________________________________

____

4. ______________________________

____

5. ______________________________

____

6. ______________________________

____

b. Portable generators (in some instances) are not required to be grounded to earth.

Article part ______________ *Code* section ________

True ________ False ________

c. In grounding separately derived AC systems, "the grounding electrode shall be as near as practicable to and preferably in the same area as the grounding electrode conductor connection to the system."

Article part ______________ *Code* section ________

True ________ False ________

d. "Bonding shall be ______________ where necessary to ensure electrical continuity and the capacity to conduct safely any ________ ________ likely to be imposed."

Article part ______________ *Code* section ________

e. An ________ or ________ conductor larger than #6 copper shall be permitted, at the time of installation, to be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is ______________.

Article part ______________ *Code* section ________

f. A bonding ________ shall be a wire, bus, screw or similar suitable conductor.

Article part ______________ *Code* section ________

g. The equipment bonding jumper shall be permitted to be installed ________ or ________ of a raceway or enclosure.

Article part ______________ *Code* section ________

h. Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250.122, but shall not be required to be larger than the circuit conductors supplying the equipment.

Give the sizes of copper equipment grounding conductors for 100-ampere, 200-ampere, and 400-ampere circuits.

Article part ____________________ *Code* section __________

100A = ______________

200A = ______________

400A = ______________

i. "____________________ or ____________________ of instrument transformers shall be grounded where accessible to other than qualified persons."

Article part ____________________ *Code* section __________

j. Where more than one equipment grounding conductor enters a box, all such conductors shall be ______________ or joined within the box or to the box with devices suitable for the use. Connection depending solely on ______________ shall not be used.

Article part ____________________ *Code* section __________

Directions Part 2

Use the *National Electrical Code*, Articles 334 through 368, to find the following information. Write the correct answers in the appropriate blanks.

a. Type NM cable shall not be installed in a shallow chase in masonry walls.

True ________ False ________

b. Protective guard strips are required for Romex and NM cable within 7 feet of the nearest edges of an accessible attic entrance; however, where the space is not accessible by permanent stairs or ladders, the guard strips shall be within ____________ feet of the attic entrance.

Code section __________

c. Intermediate metal conduit is not acceptable as an equipment grounding conductor.

True ________ False ________ *Code* section __________

d. Aluminum fittings and enclosures are permitted on steel rigid metal conduit runs.

True ________ False ________ *Code* section __________

e. Aluminum fittings and enclosures are permitted on steel rigid metal conduit runs.

True ________ False ________ *Code* section ________

f. Rigid nonmetallic conduit sizes $^1/_2$ inch to 1 inch are to be supported at 3-foot (900mm) intervals.

True ________ False ________ *Code* section ________

g. Electrical metallic tubing (EMT) conduit shall not be threaded.

True ________ False ________ *Code* section ________

h. Flexible metallic tubing runs shall not be over 6 feet long (1.8m).

True ________ False ________ *Code* section ________

i. Three-eighths-inch flexible metal conduit runs are limited to 6 feet (1.8m) in length as part of a listed assembly.

True ________ False ________ *Code* section ________

j. A busway is considered to be a grounded metal enclosure containing factory-mounted bare or insulated conductors.

True ________ False ________ *Code* section ________

Directions Part 3

Use the *National Electrical Code,* Articles 430 through 501, to find the following information. Write the correct answers in the eh appropriate blanks.

a. In marking motors, the nameplate is to show both rated volts and full-load amperes; for multispeed motors, the nameplate is to show full-load amperage for each speed, except shaded-pole and permanent-split capacitor motors where amperage is required only for maximum speed.

True ________ False ________ *Code* section ________

b. The circuit of a control apparatus that carries the electric signals directing the performance of the controller, but does not carry the main power current, is called a ________________
________________ ________________

True ________ False ________ *Code* section ________

c. The disconnecting means for a torque motor shall have an ampere rating of at least 125 percent of the motor nameplate current.

True ________ False ________ *Code* section ________

d. The branch circuit for an air conditioner compressor unit may have a short circuit protection device rated no greater than 225 percent of the motor rated-load, current or branch-circuit selection current, whichever is greater.

True _________ False _________ *Code* section __________

e. The ampacity of the conductors from the generator terminals to the first distribution device(s) containing overcurrent protection shall not be less than 125 percent of the nameplate current rating.

True _________ False _________ *Code* section __________

f. Water pipes intended for vault fire protection or transformer cooling are permitted in a transformer vault.

True _________ False _________ *Code* section __________

g. A sealed cell or battery may have a vent opening but no opening to add battery fluid.

True _________ False _________ *Code* section __________

h. Class I hazardous locations are those having to do with hazardous gases or vapors.

True _________ False _________ *Code* section __________

i. Conduit seals in Class I, Division 1 hazardous locations shall be 24 inches from an enclosure for switching.

True _________ False _________ *Code* section __________

Directions Part 4

Use the *National Electrical Code* to find the following information. Answers may be found throughout the *Code*.

a. Underground service-lateral conductors supplying only limited loads of a single branch circuit-such as small polyphase power, controlled water heaters, and similar loads-shall not be smaller than No. ___________ copper or No. ___________ aluminum or copper-clad aluminum.

Code section __________

b. A #18 fixture wire is considered to be protected by a 20-ampere breaker.

True _________ False _________ *Code* section __________

c. Conduit bodies shall not contain splices, taps, or devices unless they are durably and legibly marked by the manufacturer with their cubic inch capacity.

True _________ False _________ *Code* section __________

d. "All pull boxes, junction boxes, conduit bodies, and fittings shall be provided with ______________________ compatible with the box."

Code section __________

e. Where bare or covered conductors are used with insulated conductors, their allowable ampacities shall be limited to those permitted for the adjacent insulated conductors.

True _________ False _________ *Code* section __________

f. Type NM or NMC cable "shall comply with *Code* section __________ where installed through or parallel to joists, studs, rafters, or similar wood or metal members."

Code section __________

g. Capacitors 600 volts nominal and under shall be provided with a means of draining the stored charge to 50 volts or less within ______________ ______________________ after being disconnected from power source.

Code section __________

h. Hazardous locations Class II, Group E are those that are hazardous because of the presence of combustible metal dust.

True _________ False _________ *Code* section __________

i. "All 125-volt receptacles located within (7.5) feet of the inside walls of a pool shall be protected by a ground-fault circuit-interrupter."

True _________ False _________ *Code* section __________

1016

Objective 11

Assignment Sheet 1—Determine the Correct Number of Conductors for Boxfill

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Correct rule used	______
• Nine of ten answers correct per assignment sheet answers	______

Basic Skills

Reading Mathematics

Directions

Determine the correct number of conductors for boxfill for the problems below. To find boxfill, subtract two conductors per device and one conductor per one or more ground from the maximum allowed number of conductors permitted according to the *National Electrical Code,* Article 314.16 and table 314.16(A). Assume one ground wire for each problem.

Example: 4" x 2 1/8" (100 x 54) square box, two yoke- or strap-holding devices, #12 wire

1. Referring to box dimensions and wire size, locate the maximum number of conductors on chart in Table 314.16(A) (maximum number = 13).
2. Subtract two conductors for each yoke- or strap-holding device (13 – 4 = 9).
3. Subtract one conductor for ground (9 –1 = 8).
4. Answer equals boxfill (boxfill = 8 conductors).

a. 4" x 2 1/8" (100 x 54), no yoke- or strap-holding device, round box, cable clamp, #12 wire

Boxfill = ______________________ conductors

b. $3^3/_4$" x 2 x $3^1/_2$" (95 x 50 x 90), one yoke- or strap-holding device, masonry box, #12 wire

Boxfill = ______________________ conductors

c. 3" x 2 x $1^1/_2$" (75 x 50 x 38), one yoke- or strap-holding device, #10 wire

Boxfill = ______________________ conductors

d. 4" x $2^1/_8$" x $1^7/_8$" (100 x 54 x 48), one yoke- or strap-holding device, #10 wire

Boxfill = ______________________ conductors

e. 4 $^{11}/_{16}$" x $1^1/_2$" (120 x 38), two yoke- or strap-holding devices, square box, #12 wire

Boxfill = ______________________ conductors

f. 4" x $1^1/_4$" (100 x 32), round box, #12 wire

Boxfill = ______________________ conductors

g. 3" x 2" x $2^1/_2$" (75 x 50 x 65), no yoke- or strap-holding device, #10 wire

Boxfill = ______________________ conductors

1018

h. 3" x 2" x $3^1/_2$" (75 x 50 x 90), no yoke- or strap-holding device, #10 wire

Boxfill = ____________________________ conductors

i. 4" x $2^1/_8$" x $1^1/_2$" (100 x 54 x 38), no yoke- or strap-holding device, #12 wire

Boxfill = ____________________________ conductors

j. 4" x $1^1/_4$" (100 x 32), two yoke- or strap-holding devices, square box, #12 wire

Boxfill = ____________________________ conductors

Objective 12

Job Sheet 1—Install Outlet Boxes on Wood Studs on a Framed Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

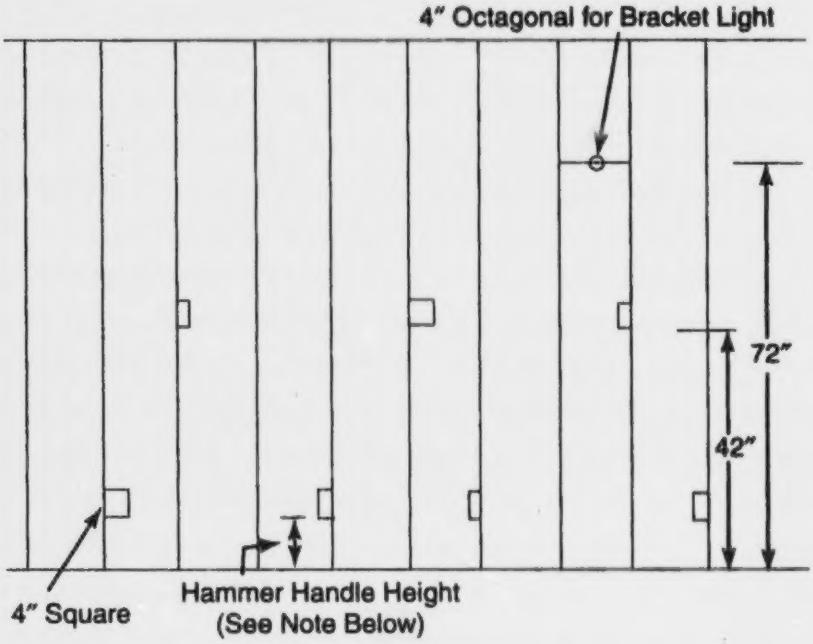
When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools, including hammer and tape
- 8-foot section of framed wall with 2" x 4" studs
- Five outlet boxes (plastic)
- Two 4-inch square boxes
- Two plaster rings
- #8 mounting nails
- 4-inch octagon box
- One expandable hanger bar
- Construction blueprint showing locations and other necessary information for box installation (Figure 1)

Job Sheet 1

Figure 1



(see note below)

Procedure

☐ 1. View blueprint for installation information to determine location of boxes.

Note: Mount boxes to allow for $^{5}/_{8}$-inch Sheetrock®.

☐ 2. Lay out job by marking studs where boxes are to be installed.

☐ 3. Place boxes on floor along wall where each is to be installed.

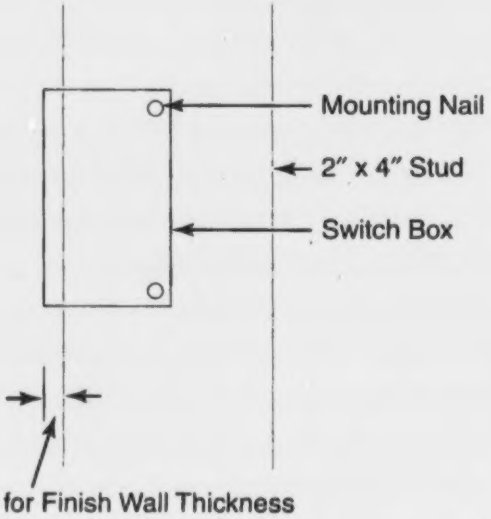
☐ 4. Measure heights, and mark studs for mounting boxes.

Note: A quick, accurate method of measuring for box installation is to cut a piece of conduit, lath, or other similar material to proper length from floor or floor plate to bottom of box. Boxes can be held on top of the measuring device and fastened to stud. This will prevent reading a rule for locating each box. A method often used in industry for height location of receptacle boxes is to set a hammer on the floor and position the box on top of the handle. The receptacle box can be fastened to the stud at that height.

☐ 5. Mount electrical boxes to studs at the locations and heights marked, with front edge of boxes parallel to face of stud and extended 1/2 inch to allow for 5/8-inch Sheetrock®.

Note: Four-inch square boxes are usually mounted with #8 or roofing nails, and switch boxes are usually mounted with #16 nails.

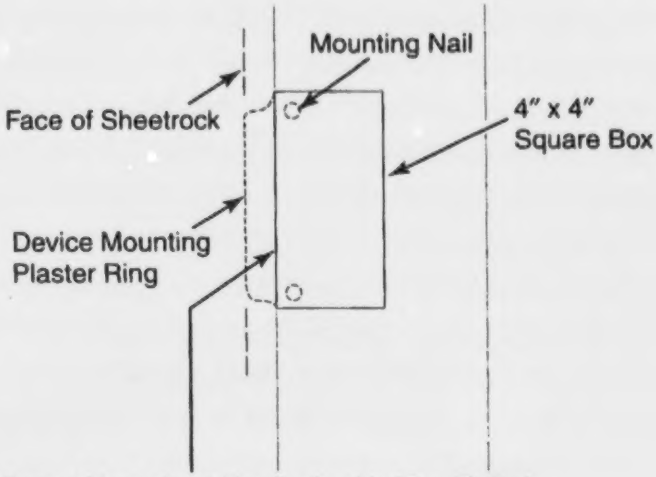
Figure 2: Switch Box Mounted on a 2″ by 4″ Wall Stud


Mounting Nail
2″ x 4″ Stud
Switch Box
Depth as Needed for Finish Wall Thickness

☐ 6. Mount 4-inch square boxes to studs at the height and location as marked with front edge of box flush with face of stud. (Figure 3)

Note: Set four-inch square boxes 1/2 inch lower than switch boxes, device screws inside.

Figure 3: 4″ by 4″ Box Mounted on 2″ x 4″ Stud


Mounting Nail
Face of Sheetrock
4″ x 4″
Square Box
Device Mounting
Plaster Ring

Front of box should be flush with 2″ x 4″ stud.

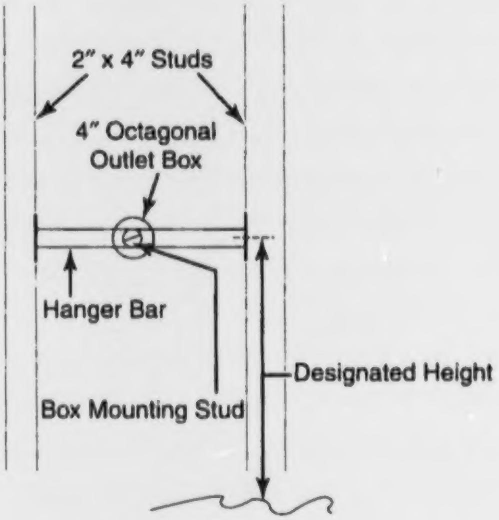
☐ 7. Install octagonal outlet box for wall bracket light between two studs at location and height marked.

  ☐ a. Spread expandable hanger bar to proper length to properly fit between studs.

  ☐ b. Attach hanger bar to studs. (Figure 4)

  Note: Hanger bars are usually fastened to studs with #8 nails.

Figure 4: 4″ Octagonal Box Mounted on Hanger Bar


2″ x 4″ Studs
4″ Octagonal Outlet Box
Hanger Bar
Designated Height
Box Mounting Stud

  ☐ c. Attach octagonal box to hanger-bar stud.

  Note: Have instructor evaluate project.

☐ 8. Clean work area, and carefully dismantle equipment and return it to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 13

Job Sheet 2—Install Outlet Boxes on Steel Structures and Rods Using Caddy Clips

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Stove bolt, $^{1}/_{4}$ inch by $^{1}/_{2}$ inch
- 3-foot piece of 1/2-inch (16) EMT
- $^{1}/_{2}$-inch EMT connector
- 4-inch square outlet box, Raco #185 or equivalent
- Two 3-foot pieces of $^{1}/_{4}$-inch rod
- Two rod-hanger clamps. Caddy Catalog #708-2-4 or equivalent
- Two conduit box clips, Caddy Catalog #4-1-2-4 or equivalent
- Pouch tools

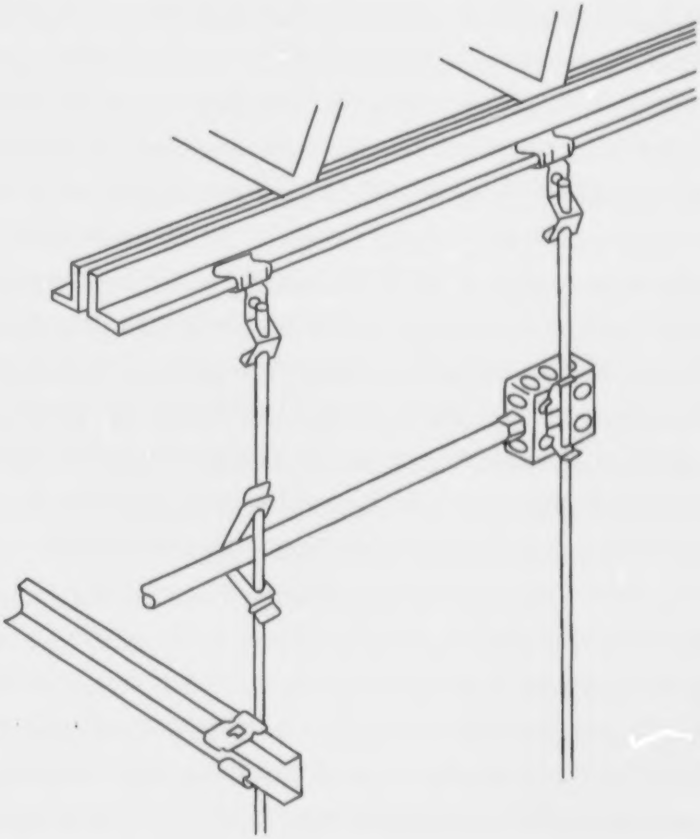
Procedure

☐ 1. Install two $^{1}/_{4}$-inch rods in rod-hanger clamps.

☐ 2. Mount two rod-hanger clamps on suspended angle iron approximately 24 inches apart.

☐ 3. Install $^1/_2$-inch (16) EMT in 4-inch square box. (Figure 1)

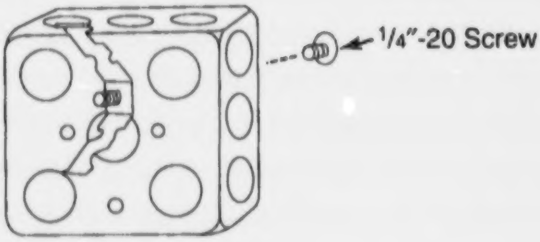
Figure 1



Used with permission of ERICO Products, Inc.

☐ 4. Fasten rod-hanger clip to square box. (Figure 2)

Figure 2

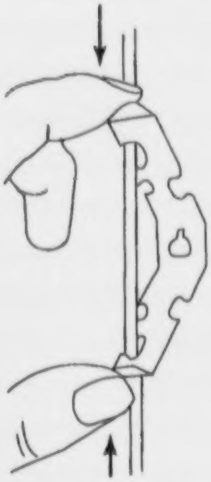


Used with permission of ERICO Products, Inc.

☐ 5. Mount box and EMT to the two 1/4-inch rods. (Figure 2)

☐ 6. Adjust to proper height. (Figure 3)

Figure 3



Used with permission of ERICO Products, Inc.

Note: Have instructor evaluate your project.

☐ 7. Clean work area, and carefully dismantle your equipment. Return it to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 14

Job Sheet 3—Install Outlet Boxes on Steel Studs Using Caddy Metal Clips for Switch Boxes

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

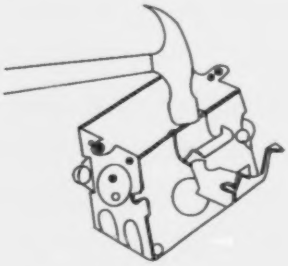
- Pouch tools
- 8-foot section of steel-stud wall
- Three electrical boxes, Raco #560 or equivalent
- 4-inch square electrical box, Raco #211 or equivalent
- Handy box, Raco #660 or equivalent
- Metal stud clip, Caddy #MSB-625 or equivalent
- Four MF clips for switch boxes, Caddy #MF-625 or equivalent

Procedure

Note: Boxes may be mounted at nonregulation places since intent of this job sheet is to acquaint students with box mounting methods when working with steel-stud walls.

☐ 1. Mount metal stud clip to switch box.

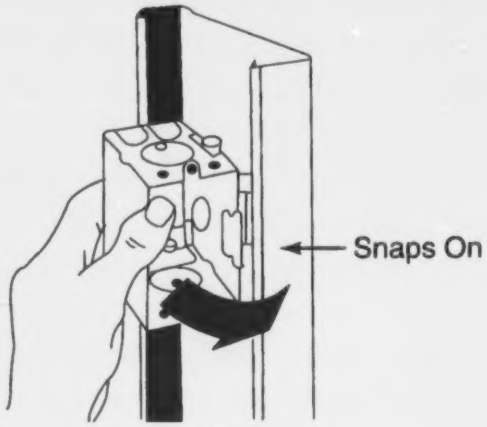
Figure 1



Used with permission of ERICO Products, Inc.

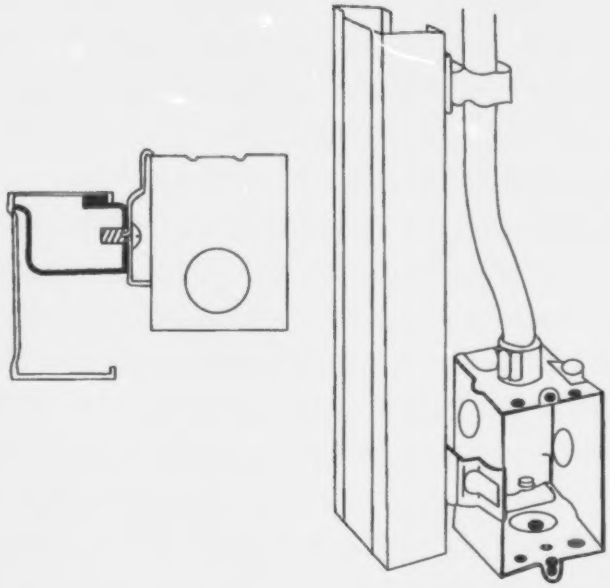
☐ 2. Mount box and clip to steel stud. (Figures 2 and 3)

Figure 2



Used with permission of ERICO Products, Inc.

Figure 3

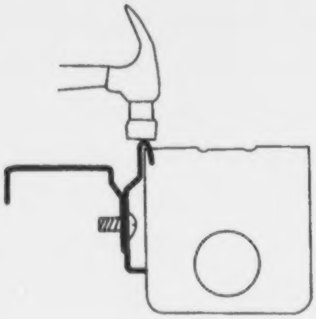


Used with permission of ERICO Products, Inc.

1029

☐ 3. Mount one MF clip on each of the other boxes. (Figure 4)

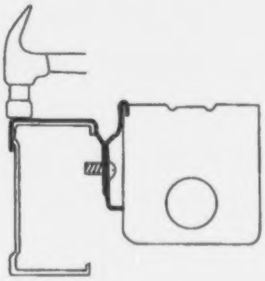
Figure 4



Used with permission of ERICO Products, Inc.

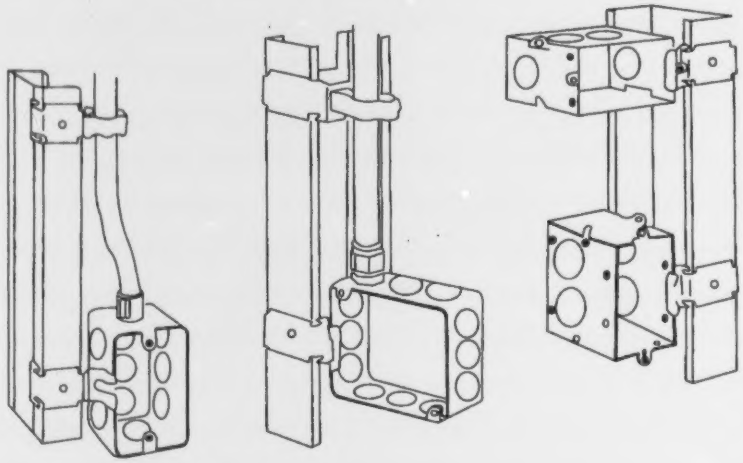
☐ 4. Mount clips and boxes to metal studs. (Figures 5 and 6)

Figure 5



Used with permission of ERICO Products, Inc.

Figure 6



Used with permission of ERICO Products, Inc.

Note: Have instructor evaluate your work.

☐ 5. Clean work area, and carefully dismantle your equipment and return it to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 15

Job Sheet 4—Install Masonry Boxes in a Block Wall Using Caddy Metal Clips for Switch Boxes

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

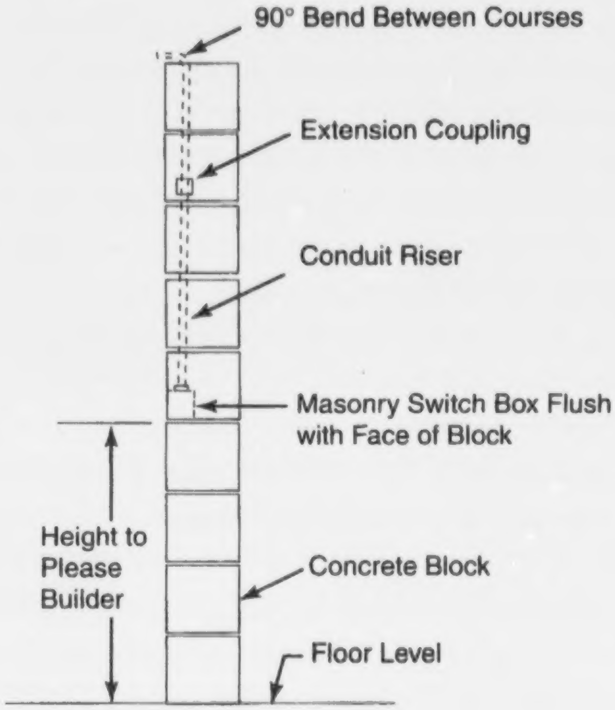
Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Hacksaw
- Two masonry switch boxes, Raco #695 or equivalent
- Two masonry two-gang boxes, Raco #696 or equivalent
- 20 feet of $^{1}/_{2}$-inch (16) EMT
- Four $^{1}/_{2}$-inch (16) EMT setscrew connectors
- Four $^{1}/_{2}$-inch (16) EMT setscrew couplings
- Conduit bender
- Plan (Figure 1)

Figure 1


90° Bend Between Courses
Extension Coupling
Conduit Riser
Masonry Switch Box Flush with Face of Block
Height to Please Builder
Concrete Block
Floor Level

Procedure

Note: This job must be done in cooperation with the masonry instructor because the electrical components are to be installed as the block wall is constructed.

☐ 1. Open 1/2-inch (16) knockout hole nearest to the back of box so that EMT will be in the hollow of the cement blocks.

Note: Masonry boxes generally have concentric 1/2-inch (16) and 3/4-inch (21) knockout punchings; exercise care to break out on the 1/2-inch part.

☐ 2. Cut eight pieces of 1/2-inch (16) EMT, approximately 30 inches long.

Note: Cut all eight pieces exactly the same length.

☐ 3. Install 1/2-inch (16) EMT connectors in each of the four masonry box knockout holes.

Note: If during knockout removal, the 3/4-inch punching breaks out instead of the 1/2-inch punching, see your instructor. You will need two 3/4-inch by 1/2-inch reducing washer for each 3/4-inch hole to properly install 1/2-inch (16) EMT.

☐ 4. Install a 40-inch piece of EMT in each connector.

Note: The person laying the blocks must install each block down over the vertical conduit.

☐ 5. Deliver the made-up boxes to the block layer.

Note: The electrician and the block layer must work together to be sure that the boxes are installed in the proper locations, and correctly installed with the EMT extending upward in the wall. See Figure 1.

☐ 6. When the block wall reaches desired height, install the masonry boxes, extending conduit upward.

☐ 7. Supervise the installation of the next layers of blocks until only a short portion of the conduit is visible above the wall.

Note: The block mason must raise the blocks above the height of the conduit, and then lower the next blocks over the conduit so that it extends upward through the hollow of the blocks.

☐ 8. Install 30-inch pieces of conduit equipped with couplings to increase the height for next layers of blocks.

Note: The conduit is extended upward 2 or 3 feet at a time as the height of the wall increases.

☐ 9. Make a 90-degree bend in the conduit when the wall and conduit reach required height.

☐ 10. Have the instructor evaluate your work.

☐ 11. Clean work area, and carefully dismantle equipment and return it to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 16

Assignment Sheet 1—Draw a Diagram of the Power Distribution Supplying Your School Shop or Home

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Accurate	______
• Neat	______
• Correctly labeled	______

Basic Skills

Reading Science

Directions

Draw a diagram showing the power distribution supplying your school shop or home. Refer to Objective 4 for assistance in completing this assignment.

Objective 17

Assignment Sheet 2—Solve Problems for Unknown Voltage

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Assignment answer complete	______
• Eight of ten answers correct per Answers to Assignment Sheet 2	______

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula from Ohm's law to find the voltage. Show calculations beside each problem.

Example 1: 2 amps, 60 Ohms = ____________ volts
Answer: 2 x 60 = 120

Example 2: 2 amps, 240 watts = ____________ volts
Answer: 240 ÷ 2 = 120

Problems

	Amps	Ohms		Calculations	Volts
a.	20	6	=		______
b.	4	60	=		______
c.	9.6	2.5	=		______
d.	5	2.4	=		______
	Amps	Watts			
e.	6	1,380	=		______
f.	6.5	715	=		______
g.	2.5	1,100	=		______
h.	5	600	=		______
i.	7	805	=		______
j.	4	500	=		______

Objective 18

Assignment Sheet 3—Solve Problems for Unknown Amperage

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answer complete	______
• Eight of ten answers correct per Answers to Assignment Sheet 3	______

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula to find the voltage. Show calculations beside each problem.

Example 1: 120 volts, 40 ohms = ____________ amps
Answer: 120 ÷ 40 = 3

Example 2: 120 watts, 120 volts = ____________ amps
Answer: 120 ÷ 120 = 1

Problems

	Volts	Ohms		Calculations	Amps
a.	230	12	=		______
b.	110	11	=		______
c.	440	20	=		______
d.	120	40	=		______
e.	24	3	=		______
	Watts	Volts			
f.	6,000	120	=		______
g.	2,640	240	=		______
h.	8,800	440	=		______
i.	690	115	=		______
j.	2,760	230	=		______

Objective 19

Assignment Sheet 4—Solve Problems for Unknown Resistances and Wattages

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answer complete	______
• Eight of ten answers correct per Answers to Assignment Sheet 4	______

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula to solve the problems. Show calculations beside each problem.

Example 1: 440 volts, 10 amps = ____________ ohms
Answer: 440 ÷ 10 = 44

Example 2: 115 volts, 12 amps = ____________ watts
Answer: 115 x 12 = 1,380

Problems

	Volts	Amps		Calculations	Ohms
a.	240	4	=		________
b.	24	9.6	=		________
c.	12	5	=		________
d.	230	5	=		________
e.	24	8	=		________
	Volts	**Amps**			**Watts**
f.	240	11	=		________
g.	115	6	=		________
h.	440	20	=		________
i.	230	50	=		________
j.	24	.5	=		________

Objective 20

Assignment Sheet 5—Solve Problems for an Unknown Quantity

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• Eight of ten answers correct per Answers to Assignment Sheet 5	______

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula from Ohm's Law to determine the correct voltage in the following problems. Show your calculations.

Example 1: A circuit is drawing a current of 2 amps, and the resistance is 60 Ohms. What is the voltage?
Answer: $E = I \times R$
$= 2 \times 60$
$= 120$ volts

Example 2: What is the resistance in a circuit drawing 4 amps through a potential of 240 volts?
Answer: $R = E/I$
$= 240/4$
$= 60$ ohms

Problems

a. If a 2.5-ohm circuit pulls 9.6 amperes, what is the voltage? __________

b. A 460-volt circuit operates at 100 amperes. What is the resistance of this circuit? __________

c. A 12-volt circuit is operating a 2.5 amps. What is the power dissipated by the circuit? __________

d. The total resistance of a circuit is 500 ohms, and the total current is 0.500 amps. What is the voltage potential? __________

e. If a circuit's power is 100 watts and the voltage is 120, what is the current draw? __________

f. How much power is produced by 208 volts at 600 amps? __________
How much is the resistance of this circuit? __________

g. If a 50-volt circuit dissipates 20 watts of power, what is the total resistance of the circuit? __________

h. At what current level will 2,200 ohms at 10 volts operate? __________
How much power will be consumed? __________

i. A potential difference of 100 volts will produce 100 watts in a circuit. What will be the resistance to the current flow? __________

j. If 1,000 amps are flowing in a 480-volt circuit, what is the total resistance? ________ How much power is being consumed? ________

BEST COPY AVAILABLE

MAVCC

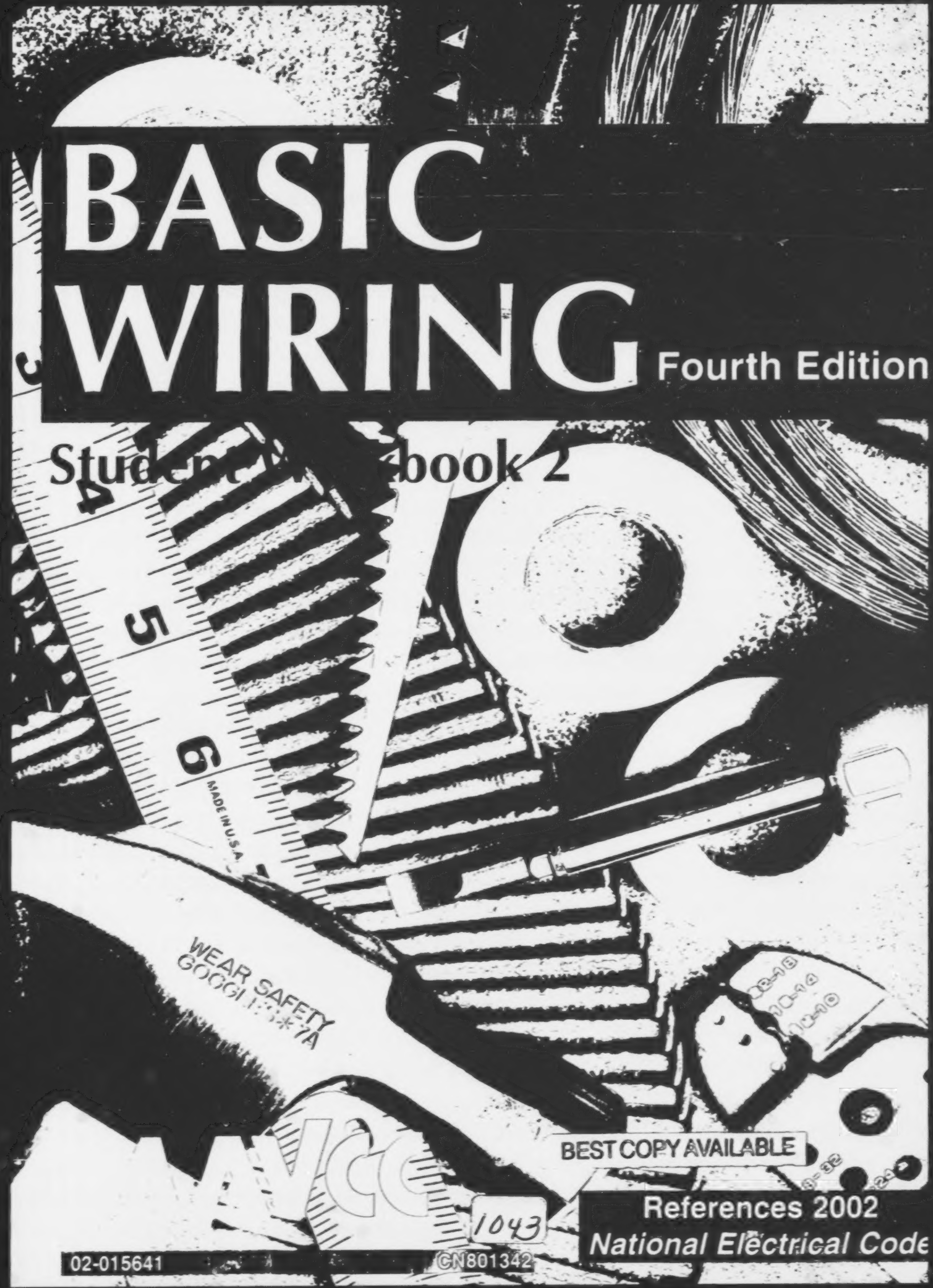
1500 West Seventh Avenue • Stillwater, OK 74074-4364
800-654-3988 • www.mavcc.com

1042

BASIC WIRING

Fourth Edition

Student Workbook 2


4
5
6
MADE IN U.S.A.
WEAR SAFETY GOGGLES*7A

VCC

BEST COPY AVAILABLE

1043

References 2002
National Electrical Code

02-015641
CN801342

Basic Wiring

Fourth Edition

Student Workbook 2

Units 10-17

Written by

Stan Kaltwasser
Gary Flowers
Don Blasingame

Revised by

Dan Ipock
Glenn Fleming

Project coordinated by

Glenn Fleming

Developed by

Multistate Academic and Vocational Curriculum Consortium, Inc.
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

©2002

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

02-015641 801342

©2002 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Printed in the United States of America by the
Oklahoma Department of Career and Technology Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Workbook Contents

Unit 10

DC Circuits

Assignment Sheets

1—Solve Problems for Unknown Current 1
2—Solve Problems for Unknown Resistance 3
3—Solve Problems for Unknown Voltage 5
4—Determine Total Resistance in Series Circuits 7
5—Determine Unknown Resistance Values in Series Circuits 9
6—Solve Problems for Unknown Current in Series Circuits 11
7—Solve Problems for Unknown Resistance in Series Circuits 13
8—Solve Problems for Unknown Voltage in Series Circuits 15
9—Apply Kirchoff's Voltage Law to Series Circuits 17
10—Solve Problems for Unknown Resistance in Parallel Circuits 19
11—Solve Problems for Unknown Current in Parallel Circuits 21
12—Apply Kirchoff's Current Law to Parallel Circuits 23
13—Solve Problems for Unknown Resistance in Series-Parallel Circuits 25
14—Solve Problems for Unknown Voltage in Series-Parallel Circuits 27
15—Solve Problems for Unknown Current in Series-Parallel Circuits 29
16—Compute Power Using Ohm's Law 31

Unit 11

AC Circuits

Focus Assignment

List Facts About Producing Electricity 33

Assignment Sheets

1—Solve RC and RL Circuit Problems 35
2—Solve Power Factor Problems 37
3—Draw a Diagram of a Single-Pole Switch on a Light 39
4—Draw a Diagram of Two Three-Way Switches on a Light 41
5—Draw a Diagram of Two Three-Way Switches and a Four-Way Switch on a Light 43

Job Sheets

1—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Switch Box 45
2—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box 55
3—Wire a Three-Way Switching Situation with the Supply Line Entering a Single Lighting Outlet 61
4—Wire a Four-Way Switching Situation with the Supply Line Entering the Lighting Outlet Box 69

Workbook Contents

Unit 12

Wiring Methods

Focus Assignment

Identify Environments and Structures Requiring Electrical Wiring Installations 77

Assignment Sheet

1—Reference The *National Electrical Code* to Identify Uses of Wiring Methods 79

Job Sheets

1—Install a Set-Screw Conduit Fitting 85
2—Install a Compression-Type Conduit Fitting 87
3—Prepare MC Cable for Termination 91
4—Install a Connector onto Liquidtight Flexible Metal Conduit 99
5—Install a Connector onto Rigid Nonmetallic Conduit 103

Unit 13

Conductors

Focus Assignment

Report on a Fire 107

Assignment Sheets

1—List Conductors in Order, By Size 109
2—Calculate Ampacity of Conductors, Given Insulation and Conductor Type 111
3—Calculate Corrected Ampacity of Conductors 113
4—Select Conductors for Various Ampacities and Temperatures . . 115
5—Calculate Ampacity of Conductors, Given Number of Conductors in Raceway 117
6—Calculate Ampacity and Conductor Sizes for Specific Types of Loads. 119
7—Select Cords for Various Applications 121
8—Select Proper Types of Insulation 123

Job Sheets

1—Install Cord on Utilization Equipment 125
2—Use a Fish Tape to Install Wire in Conduit 127
3—Prepare an Aluminum Conductor for Termination 129
4—Splice Solid Conductors Using a Wire Nut 131

1047

Workbook Contents

Unit 14

Low Voltage Wiring

Focus Assignment

List Licensing Requirements for Low Voltage Wiring Systems 137

Assignment Sheets

1—Draw a Wiring Diagram Indicating the Proper Connection for Bell Circuit Equipment 139
2—Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors 141

Job Sheets

1—Wire a Two-Button Chime Circuit 143
2—Wire Two Interconnecting Smoke Detectors 149

Unit 15

Overcurrent Protection

Focus Assignment

Identify Overcurrent Protective Devices 153

Assignment Sheet

1—Calculate Conductor and Fuse Sizes 155

Job Sheet

1—Test Cartridge Fuses 157

Unit 16

Load Centers and Safety Switches

Focus Assignment

Determine Cost of Load Center Construction 159

Assignment Sheet

1—Using the *NEC*, Answer Questions Related to Load Centers .. 161

Job Sheets

1—Install a Safety Switch 163
2—Wire a Load Center or Breaker Panel 165
3—Wire a Receptacle Circuit to a Load Center 169

1048

Workbook Contents

Unit 17

Existing Structures

Assignment Sheet

1—Determine the Number of Conductors Allowed to Be Added to an Existing Conduit 173

Job Sheets

1—Install a Metallic Box with Dry-Wall Grips in a Plasterboard Wall . . . 175
2—Secure a Box with Dry-Wall Supports (Box Tins) 179
3—Install a Plastic Box with Dry-Wall Grips in a Plasterboard Wall 183
4—Install a Box in a Paneled Wall 187
5—Install a Box in a Concrete Block Wall 191
6—Install a Box in a Brick Wall 195
7—Install a Box in a Ceiling with an Accessible Attic 201
8—Install Cable Between an Existing Box and a Newly Installed Box Horizontally Along a Wall in a Channel Behind Bare Board 205
9—Install Cable Between an Existing Box and a Newly Installed Box, Using an Underfloor Crawl Space 209
10—Install Cable Between an Existing Box and a Newly Installed Box, Using Attic Space 213

Objective 10

Assignment Sheet 1—Solve Problems for Unknown Current

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 1 answers	______

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula from Ohm's law to find current in the following problems. Show calculations in the space provided below each problem.

a. In a circuit having a 60-ohm resistor and a voltage of 15 volts, what is the current?

____

b. In a circuit having a 30-ohm resistor and a voltage of 24 volts, what is the current?

____

c. In a circuit having a 20-ohm resistor and a voltage of 12 volts, what is the current?

____

d. In a circuit having a 60-ohm resistor and a voltage of 120 volts, what is the current?

____

e. In a circuit having a 90-ohm resistor and a voltage of 80 volts, what is the current?

____

Objective 11

Assignment Sheet 2—Solve Problems for Unknown Resistance

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Computed all problems and showed work	_____
• Labeled answers with correct unit of measurement	_____
• Computed a minimum of four of the five answers correctly per Assignment Sheet 2 answers	_____

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula from Ohm's law to find resistance in the following problems. Show calculations in the space provided below each problem.

a. Compute the resistance in a circuit with 12 volts and 2 amps. __________

b. Compute the resistance in a circuit with 120 volts and 5 amps. __________

c. Compute the resistance in a circuit with 100 volts and 15 amps. __________

d. Compute the resistance in a circuit with 24 volts and 1 amps. __________

e. Compute the resistance in a circuit with 16 volts and 0.2 amps. __________

Objective 12

Assignment Sheet 3—Solve Problems for Unknown Voltage

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 3 answers	______

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula from Ohm's law to find voltage in the following problems. Show calculations in the space provided below each problem.

a. Find the voltage in a circuit having 5 amps and 100 ohms. ______________

b. Find the voltage in a circuit having 10 amps and 80 ohms. ______________

c. Find the voltage in a circuit having 20 amps and 60 ohms. ______________

d. Find the voltage in a circuit having 70 amps and 40 ohms. ______________

e. Find the voltage in a circuit having 40 amps and 20 ohms. ______________

Objective 13

Assignment Sheet 4—Determine Total Resistance in Series Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 4 answers	______

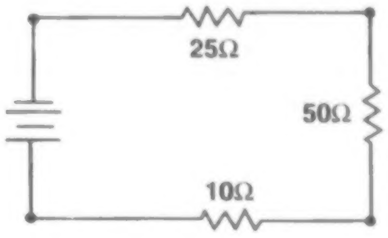
Basic Skills

Reading Mathematics

Directions

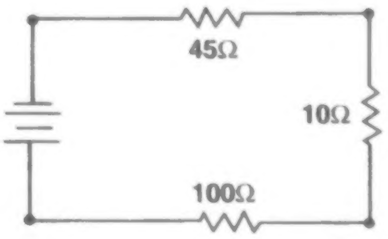
Determine the total resistance in the following series circuits. Show calculations in the space provided above each answer.

a.



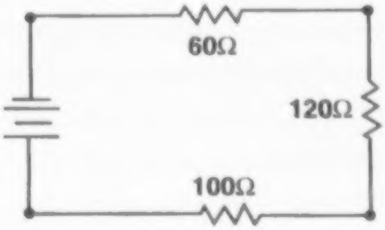
Answer ______________

b.



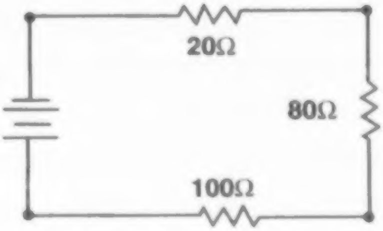
Answer ______________

c.


60Ω
120Ω
100Ω

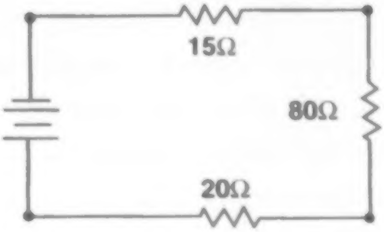
Answer ____________________

d.


20Ω
80Ω
100Ω

Answer ____________________

e.



Answer ____________________

Objective 14

Assignment Sheet 5—Determine Unknown Resistance Values in Series Circuits

Name ____________________ Overall Rating ________

Date ____________________

Evaluation Criteria	**Rating**
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 5 answers	______

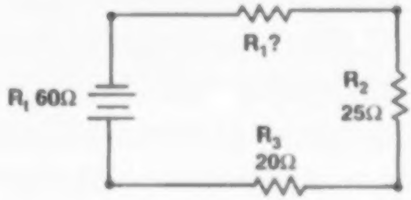
Basic Skills

Reading Mathematics

Directions

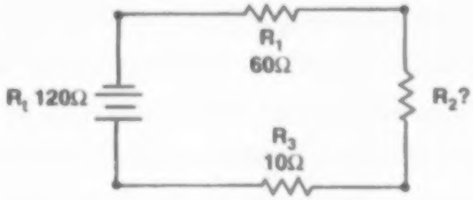
Study the following schematics and determine unknown circuit values. Show calculations in the space provided above each answer.

a.



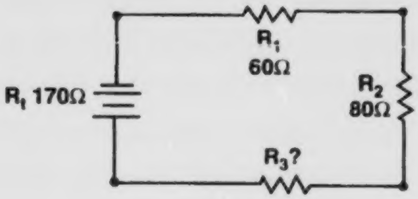
Answer ____________

b.



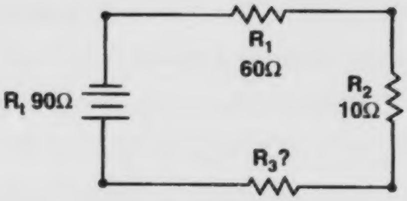
Answer ____________

c.


R₁
60Ω
R₂
80Ω
R₃?
Rₜ 170Ω

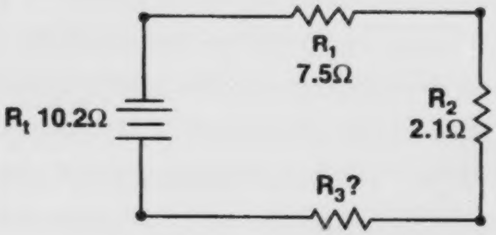
Answer __________________

d.


R₁
60Ω
R₂
10Ω
R₃?
Rₜ 90Ω

Answer __________________

e.


R₁
7.5Ω
R₂
2.1Ω
R₃?
Rₜ 10.2Ω

Answer __________________

Objective 15

Assignment Sheet 6—Solve Problems for Unknown Current in Series Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 6 answers	______

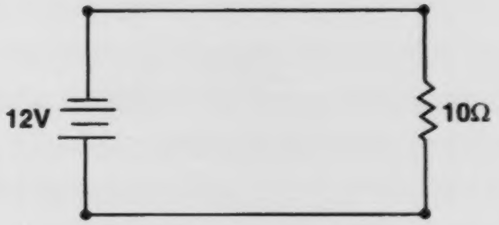
Basic Skills

Reading Mathematics

Directions

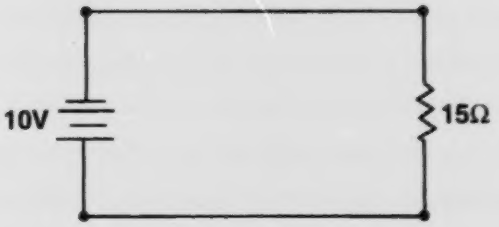
Apply the appropriate formula from Ohm's law to find the current in the following problems. Show calculations in the space provided above each answer.

a.



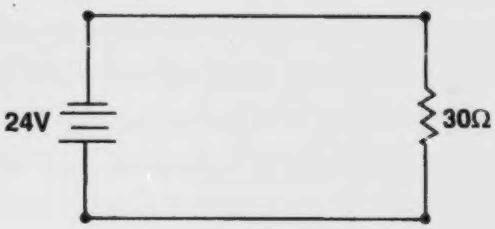
Answer ______________

b.



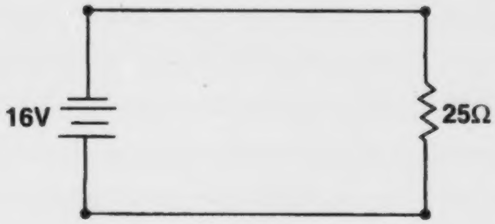
Answer ______________

c.



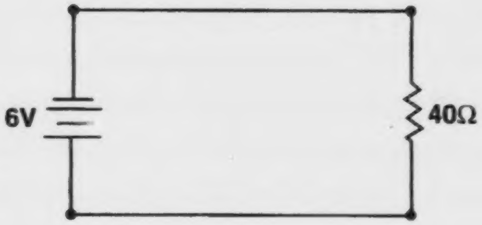
Answer ____________________

d.



Answer ____________________

e.



Answer ____________________

Objective 16

Assignment Sheet 7—Solve Problems for Unknown Resistance in Series Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 7 answers	______

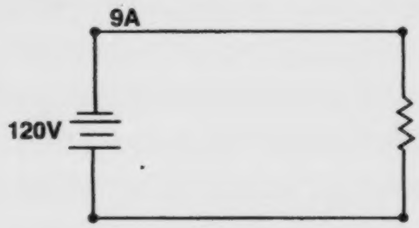
Basic Skills

Reading Mathematics

Directions

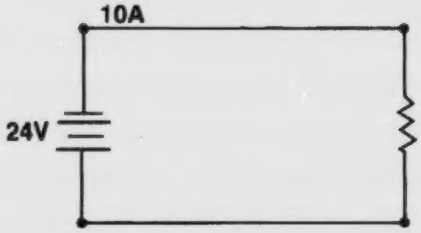
Apply the appropriate formula from Ohm's law to find resistance in the following series circuits. Show calculations in the space provided above each answer.

a.



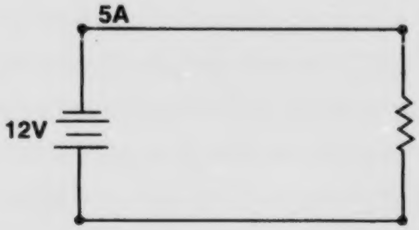
Answer ________________

b.



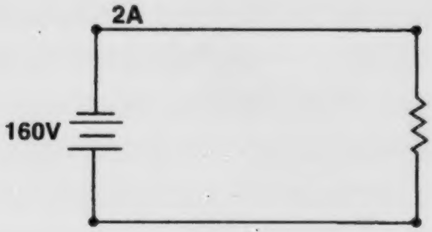
Answer ________________

c.



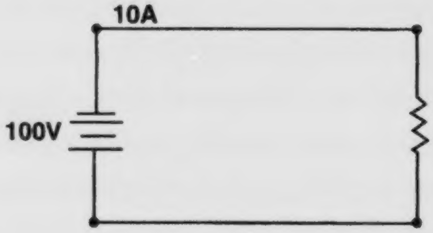
Answer ____________________

d.



Answer ____________________

e.



Answer ____________________

Objective 17

Assignment Sheet 8—Solve Problems for Unknown Voltage in Series Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 8 answers	______

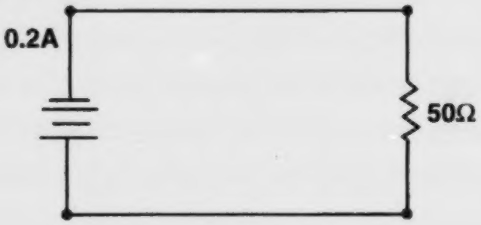
Basic Skills

Reading Mathematics

Directions

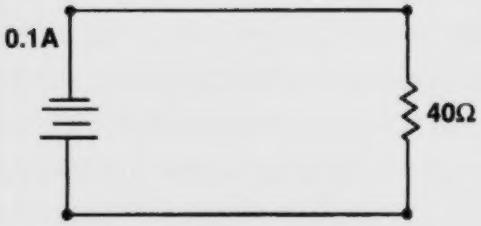
Apply the appropriate formula from Ohm's law to find voltage in the following series circuits. Show calculations in the space provided above each answer.

a.



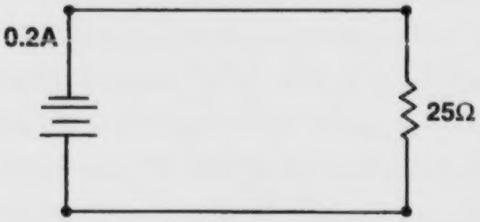
Answer ________________

b.



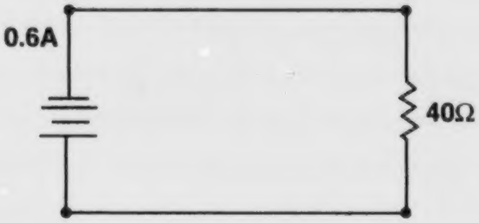
Answer ________________

c.



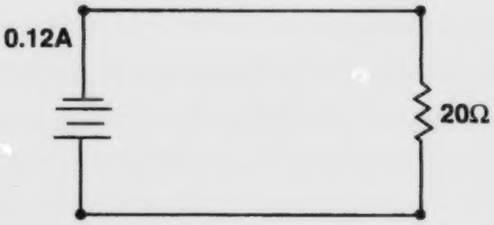
Answer ____________________

d.



Answer ____________________

e.



Answer ____________________

Objective 18

Assignment Sheet 9—Apply Kirchoff's Voltage Law to Series Circuits

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 9 answers	______

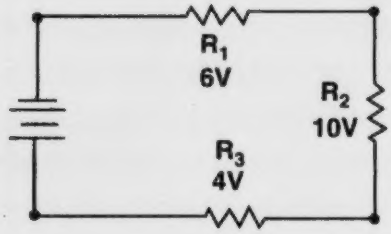
Basic Skills

Reading Mathematics

Directions

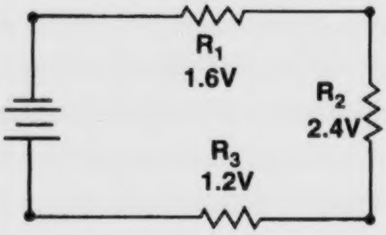
Using Kirchoff's voltage law, find voltage in the following problems. Show calculations in the space provided above each answer.

a.



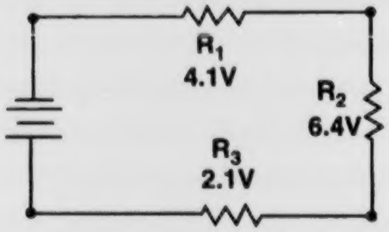
Answer ____________________

b.



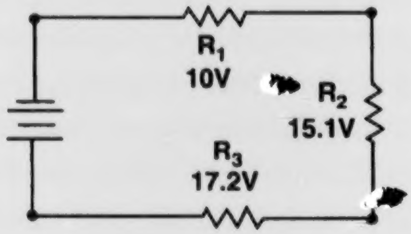
Answer ____________________

c.


R_1
4.1V
R_2
6.4V
R_3
2.1V

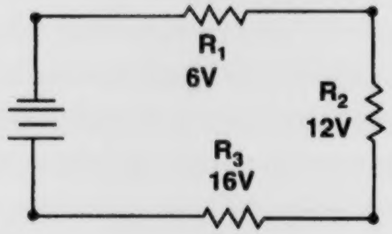
Answer ____________________

d.


R_1
10V
R_2
15.1V
R_3
17.2V

Answer ____________________

e.


R_1
6V
R_2
12V
R_3
16V

Answer ____________________

Objective 19

Assignment Sheet 10—Solve Problems for Unknown Resistance in Parallel Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Computed all problems and showed work	_____
• Labeled answers with correct unit of measurement	_____
• Computed a minimum of four of the five answers correctly per Assignment Sheet 10 answers	_____

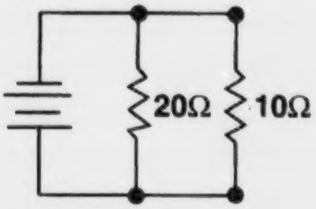
Basic Skills

Reading Mathematics

Directions

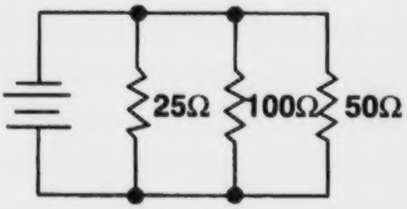
Apply the appropriate formula to find total resistance in the following problems. Show calculations in the space provided above each answer.

a.



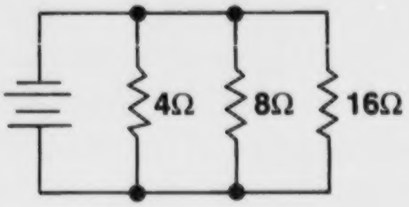
Answer ______________

b.



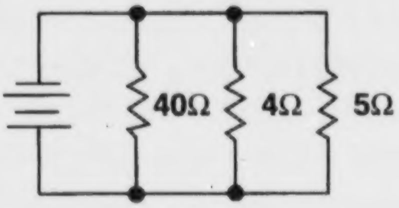
Answer ______________

c.



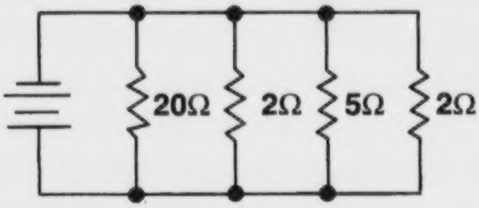
Answer ____________________

d.



Answer ____________________

e.



Answer ____________________

Objective 20

Assignment Sheet 11—Solve Problems for Unknown Current in Parallel Circuits

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 11 answers	______

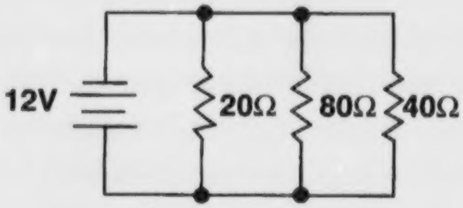
Basic Skills

Reading Mathematics

Directions

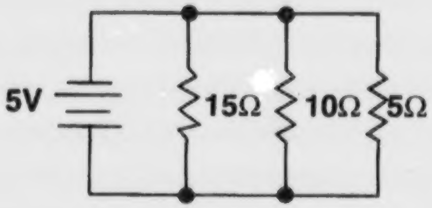
Apply the appropriate formula from Ohm's law to find current in the following problems. Show calculations in the space provided above each answer.

a.



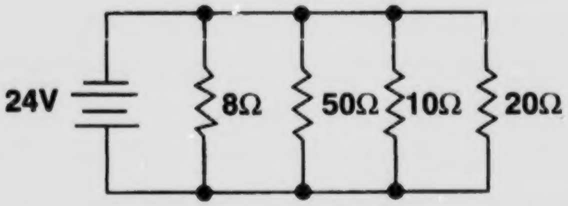
Answer ____________________

b.



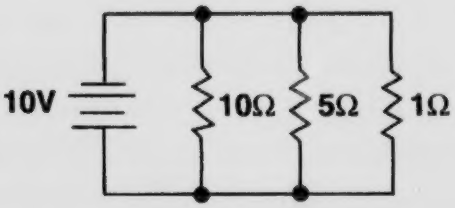
Answer ____________________

c.


24V
8Ω
50Ω
10Ω
20Ω

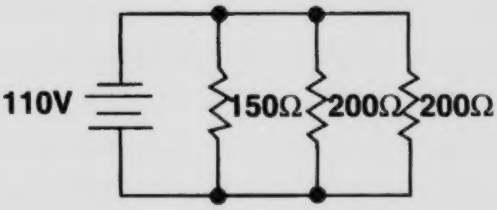
Answer ____________________

d.


10V
10Ω
5Ω
1Ω

Answer ____________________

e.


110V
150Ω
200Ω
200Ω

Answer ____________________

Objective 21

Assignment Sheet 12—Apply Kirchoff's Current Law to Parallel Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 12 answers	______

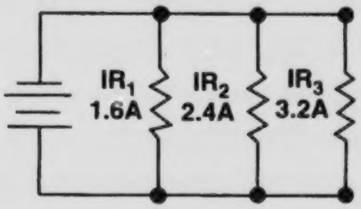
Basic Skills

Reading Mathematics

Directions

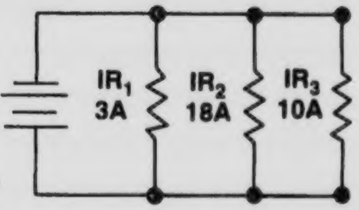
Using Kirchoff's current law, find the total current in the following problems. Show calculations in the space provided above each answer.

a.



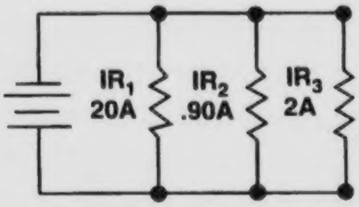
Answer ______________

b.



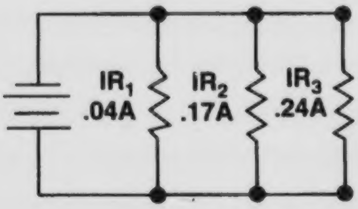
Answer ______________

c.


IR_1
20A
IR_2
.90A
IR_3
2A

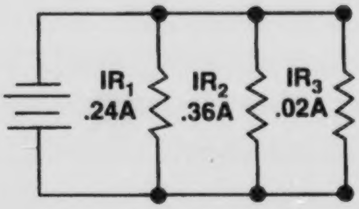
Answer ____________________

d.


IR_1
.04A
IR_2
.17A
IR_3
.24A

Answer ____________________

e.


IR_1
.24A
IR_2
.36A
IR_3
.02A

Answer ____________________

Objective 22

Assignment Sheet 13—Solve Problems for Unknown Resistance in Series-Parallel Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of two of the three answers correctly per Assignment Sheet 13 answers	______

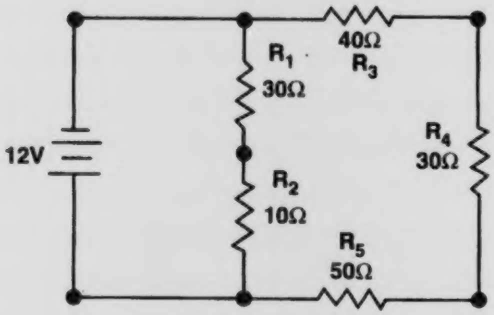
Basic Skills

Reading Mathematics

Directions

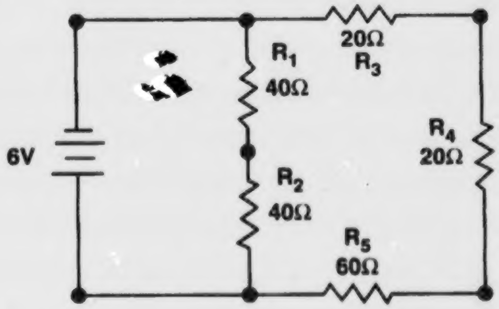
Apply the appropriate formula from to find total resistance in the following problems. Show calculations in the space provided above each answer.

a.



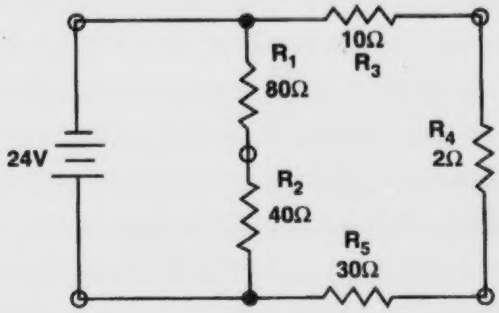
Answer ______________

b.


6V
R1
40Ω
R2
40Ω
20Ω
R3
R4
20Ω
R5
60Ω

Answer ________________

c.


24V
R1
80Ω
R2
40Ω
10Ω
R3
R4
2Ω
R5
30Ω

Answer ________________

Objective 23

Assignment Sheet 14—Solve Problems for Unknown Voltage in Series-Parallel Circuits

Name ______________________ Overall Rating __________

Date ______________________

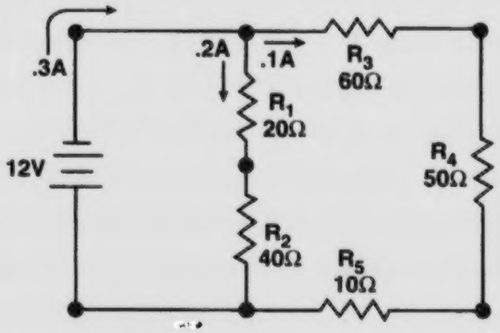
Evaluation Criteria	Rating
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 14 answers	______

Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula to find voltage in the following problems. Show calculations in the space provided below each answer.



a. Find voltage drop across R_1. ______________

b. Find voltage drop across R_2. ______________

c. Find voltage drop across R_3. ______________

d. Find voltage drop across R_4. ______________

e. Find voltage drop across R_5. ______________

Objective 24

Assignment Sheet 15—Solve Problems for Unknown Current in Series-Parallel Circuits

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 15 answers	______

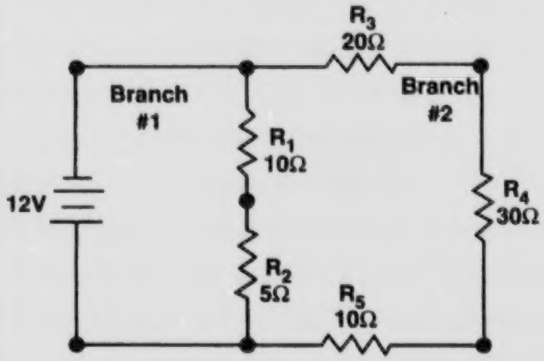
Basic Skills

Reading Mathematics

Directions

Apply the appropriate formula to find current in the following problems. Show calculations.

a.



1. Total current ______________

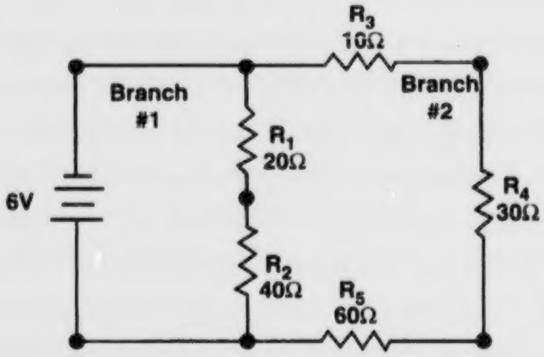
2. Total current

Branch #1 ______________

3. Total current

Branch #2 ______________

b.


R_3
10Ω
Branch
#1
Branch
#2
R_1
20Ω
6V
R_4
30Ω
R_2
40Ω
R_5
60Ω

1. Total current ______________

2. Total current

   Branch #1 ______________

3. Total current

   Branch #2 ______________

Objective 25

Assignment Sheet 16—Compute Power Using Ohm's Law

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Computed all problems and showed work	______
• Labeled answers with correct unit of measurement	______
• Computed a minimum of four of the five answers correctly per Assignment Sheet 16 answers	______

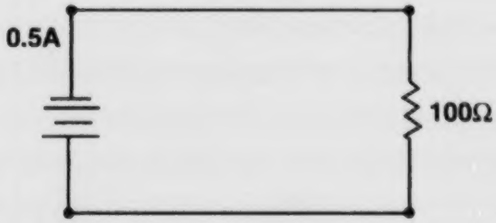
Basic Skills

Reading Mathematics

Directions

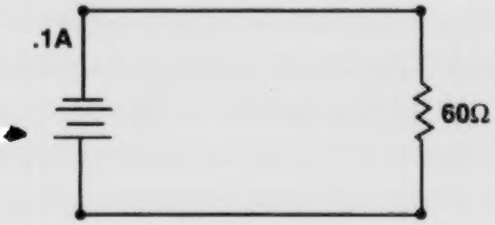
Apply Ohm's law to determine power in the following problems. Show calculations in the space provided above each answer.

a.



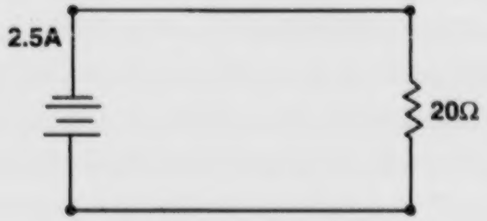
Answer ____________________

b.



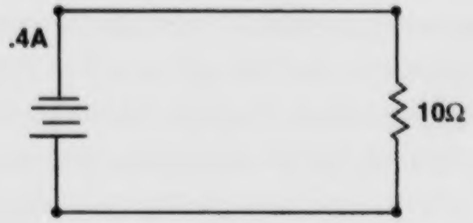
Answer ____________________

c.



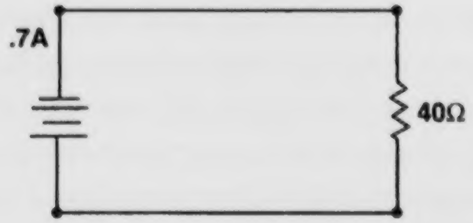
Answer ____________________

d.



Answer ____________________

e.



Answer ____________________

Objective 19

Focus Assignment 1—List Facts About Producing AC Electricity

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Completed assignment	______
• Prepared for discussion	______

Basic Skills

Reading Writing

Introduction

Electricity is produced utilizing many different manufacturing processes, and there are advantages and disadvantages to using each process.

Directions

Below you will find several different processes for producing electricity. List the advantages and disadvantages of using each process to produce electricity. Use the *NEC*, encyclopedias, the internet, or instructor supplied resources to complete this assignment. Be prepared to discuss your conclusions in class.

Hydroelectric

Advantages: ____

____

____

Disadvantages: ____

____

____

Coal

Advantages ____

____

____

Disadvantages: ____________________

____

____

Nuclear

Advantages: ____________________

____

____

Disadvantages: ____________________

____

____

Solar (Photovoltaic Systems)

Advantages: ____________________

____

____

Disadvantages: ____________________

____

____

Wind

Advantages: ____________________

____

____

Disadvantages: ____________________

____

____

Objective 20

Assignment Sheet 1—Solve RC and RL Circuit Problems

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• Minimum of four of five answers correct per Answers to Assignment Sheet 1	______

Basic Skills

Reading Mathematics

Directions

Using the formulas given in Objectives 15 and 16 of the Information Sheet for RC and RL circuits, solve the following problems. Show calculations in the space provided below each answer.

a. A 0.3 farad capacitor is operating on a 60-hertz AC signal. What will be its capacitive reactance? ______________

b. A 200-microfarad capacitor is connected to a 208-volt circuit at 60 hertz. What is the current in the circuit? ______________

c. What is the inductive reactance of a 350-millihenry choke at 60 hertz? ______________

d. What is the current flow through a 500-millihenry choke when 100 volts at 60 hertz is applied? ____________

e. What is the impedance of a 600-millihenry inductor in series with 2,200Ω, with 480 volts at 60 hertz applied? ____________

Objective 21

Assignment Sheet 2—Solver Power Factor Problems

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• Minimum of seven of eight answers correct per Answers to Assignment Sheet 2	______

Basic Skills

Reading Mathematics

Directions

Find the power factor for the following problems. Show calculations in the space provided below each answer.

a. A voltmeter reads 200 volts and an ammeter reads 10 amps. The wattmeter has a reading of 1,400 watts. What is the power factor? ____________

b. What is the power factor on a device having 150 volts, 14 amps, and a watt reading of 1,600 watts? ____________

c. What is the power factor on a device with a 120-volt and 12-amp rating on a circuit and a true power of 1,200 watts? ____________

d. What is the power factor when the true power on a circuit is 1,400 watts and the apparent power is 2,000 watts? ____________

e. What is the power factor when the true power on a circuit is 1,700 watts and the apparent power is 2,000 watts? ____________

f. A three-phase 480-volt circuit is pulling 250 amps. A wattmeter reads 13.9 kilowatts. What is the power factor? ______________

g. A 240-volt, three-phase motor is pulling 15 amps. The wattmeter reads 6 kilowatts. What is the motor's power factor? ______________

h. Twenty amperes are drawn by a 208-volt, three-phase circuit. A wattmeter records 6.35 kilowatts. What is the power factor? ______________

Objective 22

Assignment Sheet 3—Draw a Diagram of a Single-Pole Switch on a Light

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• All connections indicated	______
• Correct symbols used	______
• Circuit wiring correct configuration per Answers to Assignment Sheet 3	______

Basic Skills

Reading Writing

Directions

In the space provided, draw a diagram of a single-pole switch on a light.

Objective 23

Assignment Sheet 4—Draw a Diagram of Two Three-Way Switches on a Light

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• All connections indicated	______
• Correct symbols used	______
• Circuit wiring correct configuration per Answers to Assignment Sheet 4	______

Basic Skills

Reading Writing

Directions

In the space provided, draw a diagram of two three-way switches on a light.

Objective 24

Assignment Sheet 5—Draw a Diagram of Two Three-Way Switches and a Four-Way Switch on a Light

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• All connections indicated	______
• Correct symbols used	______
• Circuit wiring correct configuration per Answers to Assignment Sheet 5	______

Basic Skills

Reading   Writing

Directions

In the space provided, draw a diagram of two three-way switches and a four-way switch on a light.

Objective 25

Job Sheet 1—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Switch Box

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability Science

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 12-2-G or 14-2-G NM cable
- Device box
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- $^{3}/_{8}$-inch cable clamp to fit a $^{1}/_{2}$-inch knockout
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Long-nose pliers
- Lineman's pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- $^{1}/_{2}$-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses
- 120-volt incandescent bulb
- Portable GFCI
- Staples
- Single-pole switch
- Light socket

Job Sheet 1

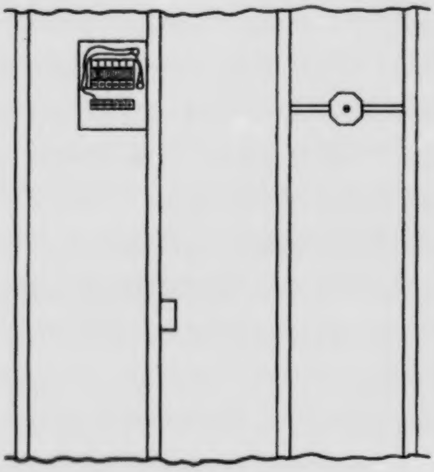
Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes.

Note: The switch box and ceiling outlet can be mounted at any height in this project.

Figure 1

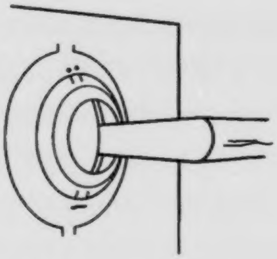


☐ 3. Remove a $^1/_2$-inch knockout from the panel.

a. Locate 1/2-inch knockout to be removed.

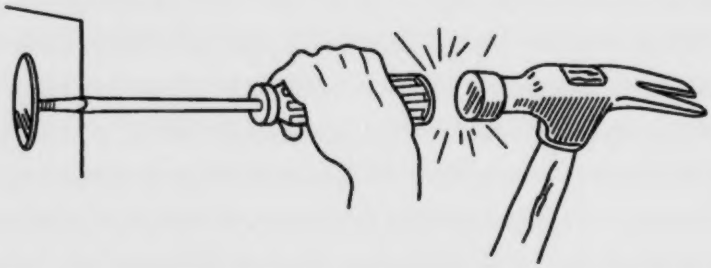
b. Place screwdriver on KO at point opposite unstamped piece.

Figure 2



c. Hit screwdriver handle crisply with hammer.

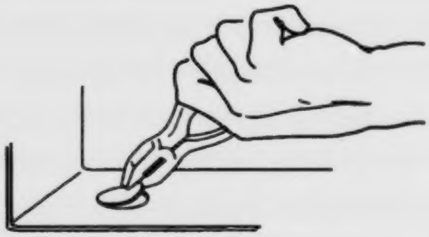
Figure 3



d. Grasp raised KO with lineman's pliers.

e. Bend KO back and forth until removed.

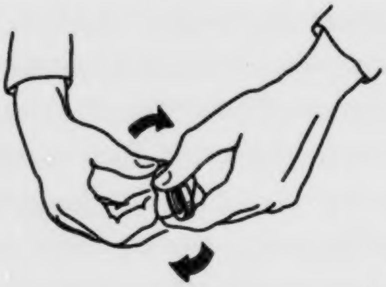
Figure 4



☐ 4. Install cable connector.

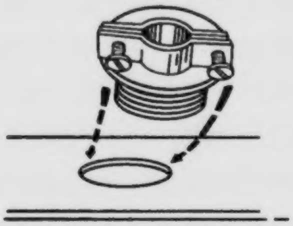
a. Hold connector and unscrew locknut.

Figure 5



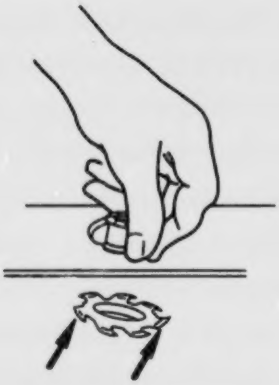
b. Place threads through KO opening.

Figure 6



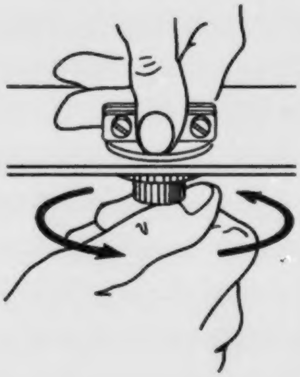
c. Install locknut.

Figure 7



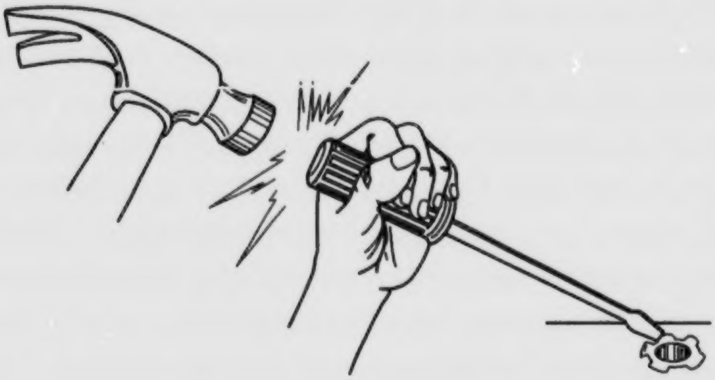
d. Tighten locknut, making sure serrated teeth are in contact with box.

Figure 8



e. Tighten locknut securely.

Figure 9



☐ 5. Plug cord into portable GFCI.

☐ 6. Bore holes for cable.

Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

Caution: Be sure to hold the drill securely. A loose grip can cause an accident.

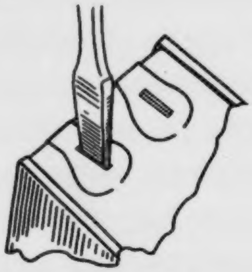
7. Run cable.

☐ a. Remove KO's from boxes.

(1) Place screwdriver in slot.

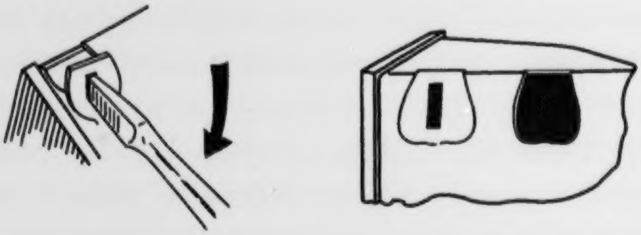
Note: This is for metallic boxes; most nonmetallic boxes have KOs that are broken out by placing a screwdriver in the center and hitting it with your hand or hammer.

Figure 10



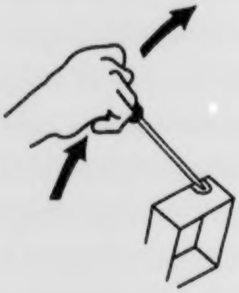
(2) Pry out KO

Figure 11



(3) Wiggle screwdriver until KO pops loose.

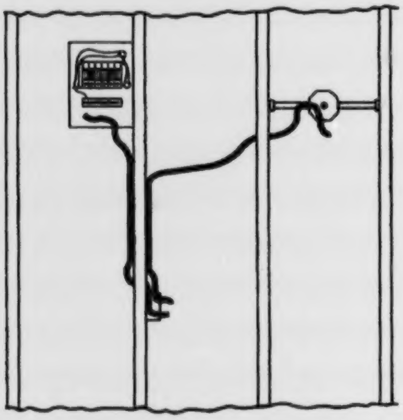
Figure 12



☐ b. Run cable between boxes.

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 13



☐ 8. Staple cable within 12 inches of all metallic boxes, 8 inches of all nonmetallic boxes.

Note: Cables should be run flat when possible.

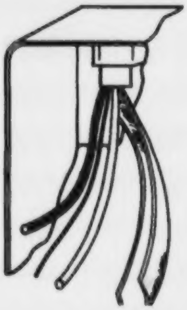
☐ 9. Secure all cable clamps and connectors.

> **Caution**: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

☐ 10. Strip cable insulation to within 1/4 inch of its point of entry.

> **Caution**: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.

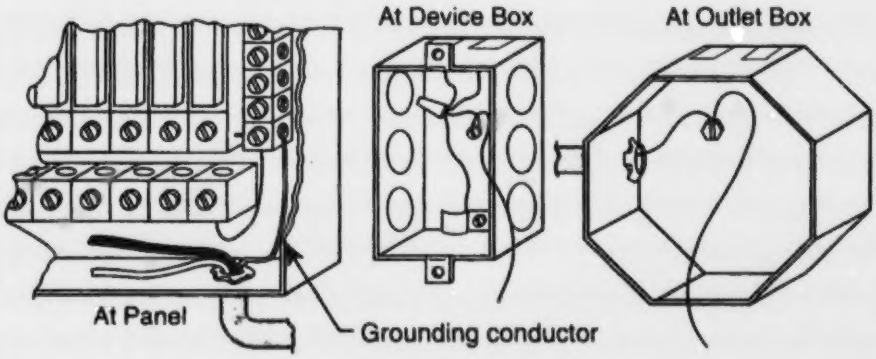
Figure 14



☐ 11. Connect all grounding conductors (green or bare).

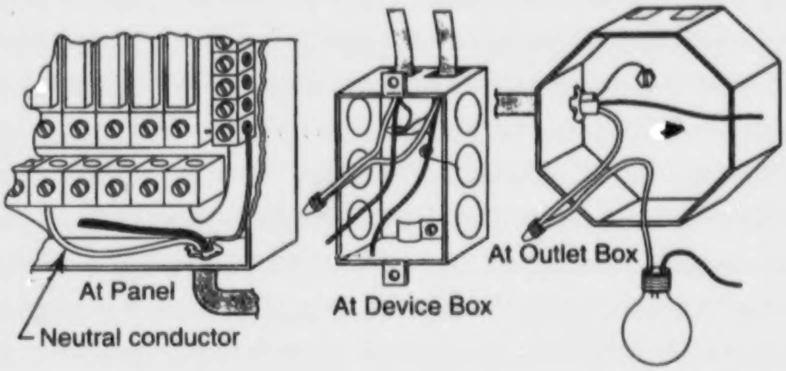
Note: Always leave enough conductor to make removal and connection easy. ***NEC* requires at least 6 inches of free conductor leaving the face of the box.**

Figure 15



☐ 12. Connect all neutral conductors (white or natural gray).

Figure 16

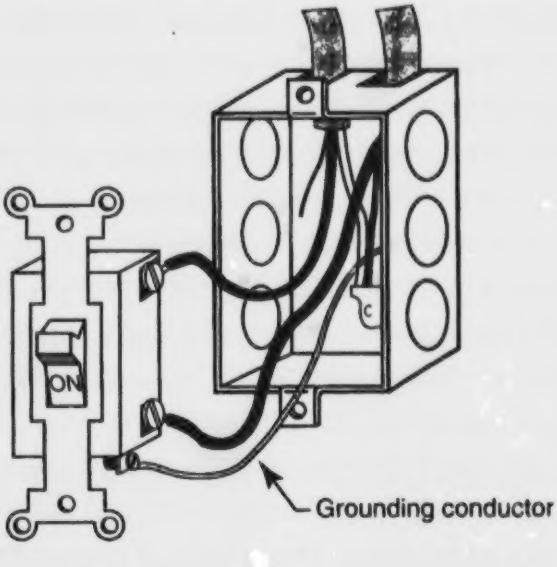

At Panel
Neutral conductor
At Device Box
At Outlet Box

☐ 13. Connect switch leg to remaining lampholder, conductor, or terminal.

☐ 14. Connect switch.

Note: Be sure that the loop in the conductors is turned in the direction that the terminal tightens, and connect neutrals together with a wire nut.

Figure 17

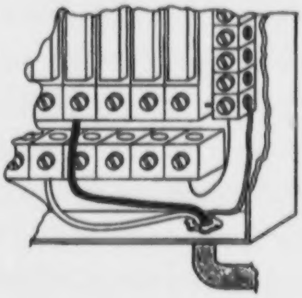

ON
Grounding conductor

☐ 15. Install the switch in box.

☐ 16. Connect ungrounded conductor to appropriate overcurrent device.

Caution: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel

Figure 18



☐ 17. Move single-pole to "off" position.

☐ 18. Turn on breaker.

Caution: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 19. Turn on switch.

☐ 20. Have your instructor evaluate this project.

☐ 21. Turn breaker off.

☐ 22. Clean work are, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 26

Job Sheet 2—Wire a Single-Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability Science

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 12-2-G or 14-2-G NM cable
- Device box
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- $^3/_8$-inch cable clamp to fit a $^1/_2$-inch knockout
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Long-nose pliers
- Lineman's pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- $^1/_2$-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses
- 120-volt incandescent bulb
- Portable GFCI
- Staples
- Single-pole switch
- Light socket

Job Sheet 2

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes.

Note: The switch box and ceiling outlet can be mounted at any height in this project.

☐ 3. Remove a 1/2-inch knockout from panel.

☐ 4. Install cable connector.

☐ 5. Plug cord into portable GFCI.

☐ 6. Bore holes for cable.

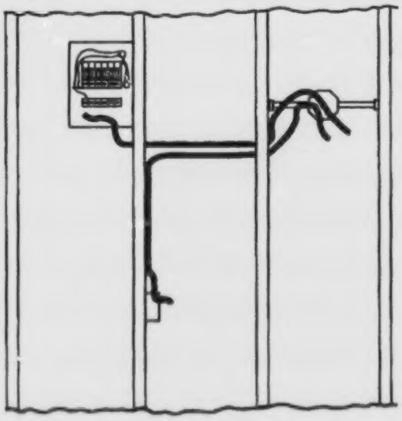
Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

Caution: Be sure to hold the drill securely. A loose grip can cause an accident.

☐ 7. Run cable.

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 1



☐ 8. Staple cable within 12 inches of all metallic boxes; 8 inches of all nonmetallic boxes.

☐ 9. Secure all cable clamps and connectors.

Caution: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

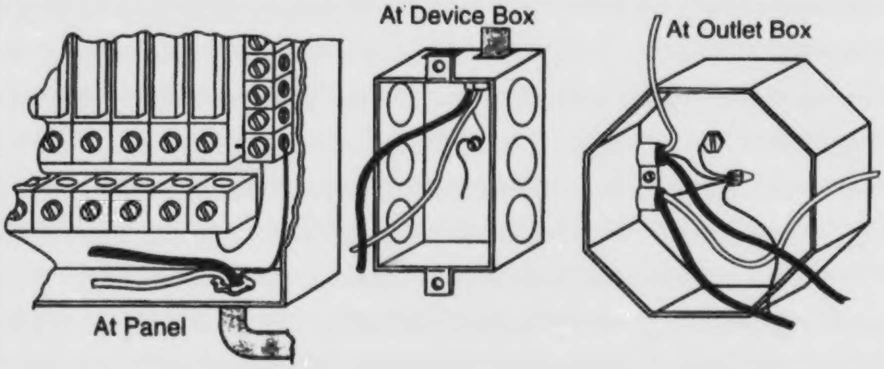
☐ 10. Strip cable insulation to within 1/4 inch of its point of entry.

Caution: Extreme care should always be sued in operations involving the knife; a cut hand can cause pain and lost work time.

☐ 11. Connect all grounding conductors (green or bare).

Note: Always leave enough conductor to make removal and connection easy. ***NEC* requires at least 6 inches of free conductor leaving the face of the box.**

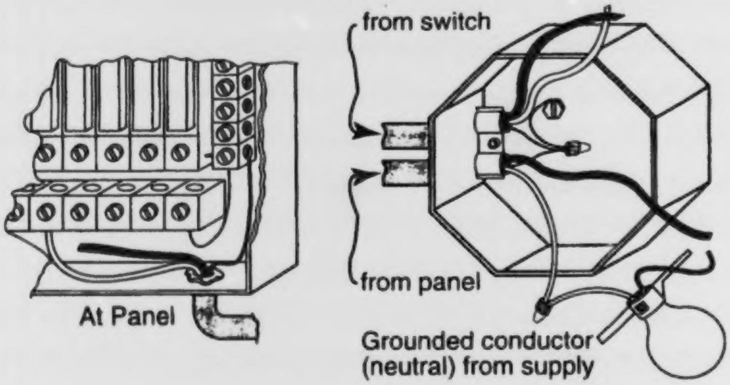
Figure 2



☐ 12. Connect all neutral conductors (white or natural gray).

Note: The grounded conductor in this circuit goes from the grounded terminal of the panel to the light, where it stops.

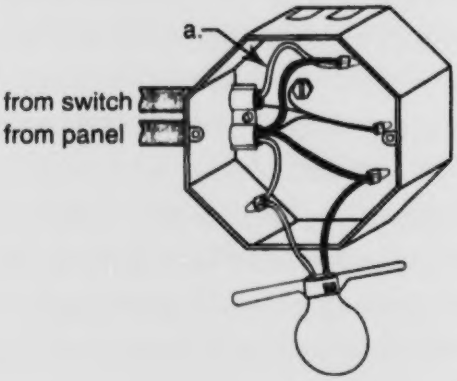
Figure 3


from switch
At Panel
from panel
Grounded conductor (neutral) from supply

☐ 13. Make up outlet box.

Note: In switching situations the technician is allowed to use the white or gray conductors as the hot feed to the switch.

Figure 4


a.
from switch
from panel

☐ 14. Install conductors on switch.

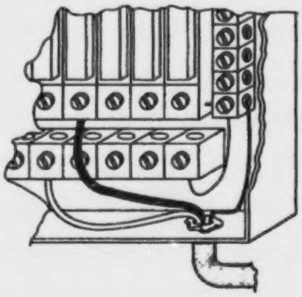
Note: It makes no difference which terminals the white and black conductors go on. The grounding, however, must go on the green, hex-head screw.

☐ 15. Install switch in box.

☐ 16. Connect ungrounded conductor to appropriate overcurrent protective device.

Caution: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.

Figure 5



☐ 17. Move single-pole to "off" position

☐ 18. Turn on breaker.

Caution: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 19. Turn on switch.

☐ 20. Have instructor evaluate this project.

☐ 21. Turn breaker off.

☐ 22. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 27

Job Sheet 3—Wire a Three-Way Switching Situation with the Supply Line Entering a Single Lighting Outlet

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability Science

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 12-2-G or 14-2-G and 12-3-G or 14-3-G NM cable
- Two device boxes
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- 3/8-inch cable clamp
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Lineman's pliers
- Needle-nose pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- 1/2-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses
- 120-volt incandescent bulb
- Portable GFCI
- Staples
- Two 3-way switches
- Light socket

Job Sheet 3

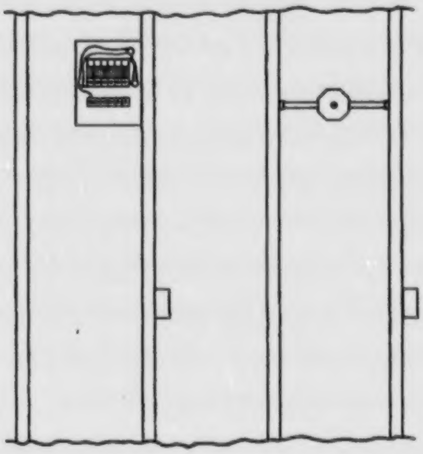
Procedure

☐ 1. Gather equipment and materials.

☐ 2. Mount boxes.

Note: The switch box and ceiling outlet can be mounted at any height in this project.

Figure 1



☐ 3. Remove a 1/2-inch knockout from panel.

☐ 4. Install cable connector.

☐ 5. Plug cord into portable GFCI.

☐ 6. Bore holes for cable.

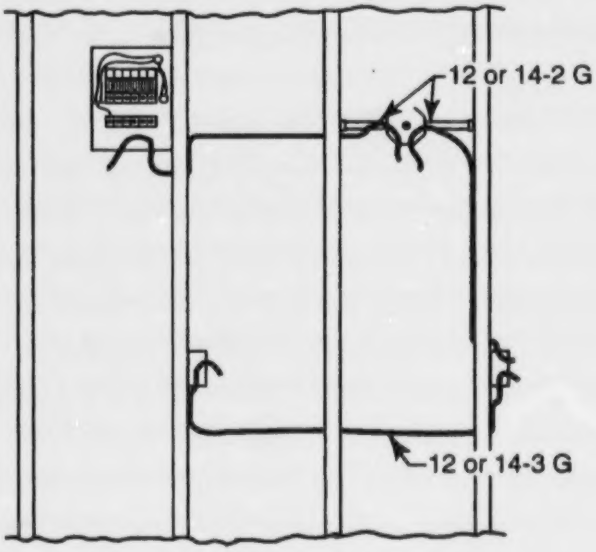
Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

> **Caution**: Be sure to hold the drill securely. A loose grip can cause an accident.

☐ 7. Run cable.

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 2



☐ 8. Staple cable within 12 inches of all metallic boxes; 8 inches of all nonmetallic boxes.

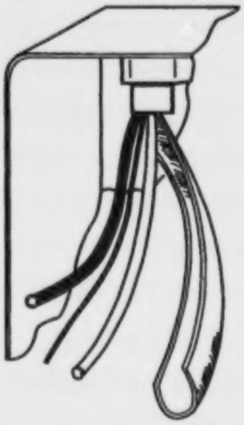
☐ 9. Secure all cable clamps and connectors.

> **Caution**: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

☐ 10. Strip cable insulation to within 1/4 inch of its point of entry.

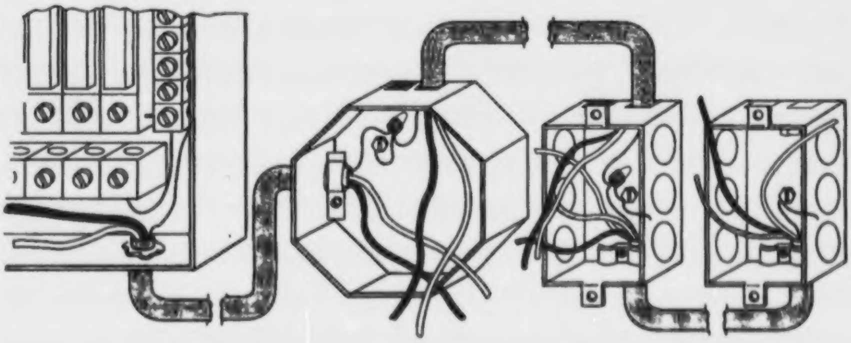
Caution: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.

Figure 3



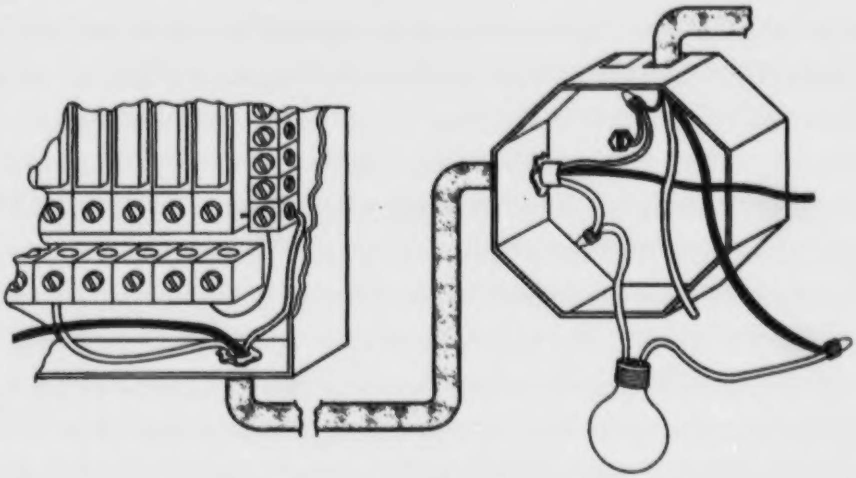
☐ 11. Connect all grounding conductors.

Figure 4



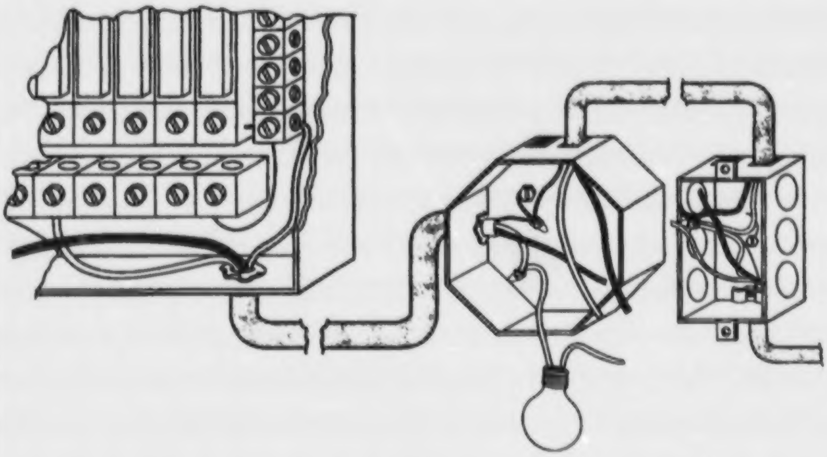
☐ 12. Connect all neutral conductors.

Figure 5



☐ 13. Connect switch legs.

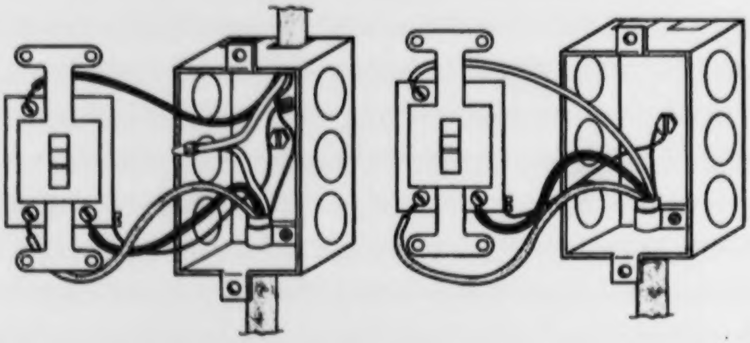
Figure 6



☐ 14. Install switches.

Note: In all three-way circuits, the switch leg ties to one common terminal, and the hot conductor ties to the other common terminal. The remaining terminals connect to the traveler conductors. The grounding screw attaches to the grounding conductor, and then to the green hex-head screw.

Figure 7

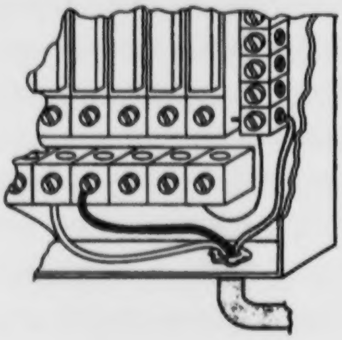


☐ 15. Connect return leg to socket.

☐ 16. Connect ungrounded conductor to appropriate overcurrent protective device.

> **Caution**: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.

Figure 8



☐ 17. Turn on breaker.

Caution: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 18. Change the position of the switches in alternating movements.

Note: Be sure that you can turn the light on or off from either switch, as well as on at one and off at the other.

☐ 19. Have instructor evaluate this project.

☐ 20. Turn breaker off.

☐ 21. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ________________________________

____

____

Objective 28

Job Sheet 4—Wire a Four-Way Switching Situation with the Supply Line Entering the Lighting Outlet Box

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability Science

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 12-2-G or 14-2-G and 12-3-G or 14-3-G NM cable
- Three device boxes
- Nonmetallic octagon box with *NEC* capacity rating to accommodate the conductors you will install
- Bar hanger (if not using a bracket octagon box or installing this job on a work board)
- Stud wall or work board
- 120-volt supply (The overcurrent supply should not exceed your conductors' *NEC* ampacity rating.)
- 3/8-inch cable clamp
- Wire connectors (Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)
- Two 16-penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain-tip screwdriver
- Lineman's pliers
- Needle-nose pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- 1/2-inch or larger wood bit for hole large enough to safely accommodate cable
- Extension cord
- Safety glasses
- 120-volt incandescent bulb
- Portable GFCI
- Staples
- Two 3-way switches
- One four-way switch
- Light socket

Job Sheet 4

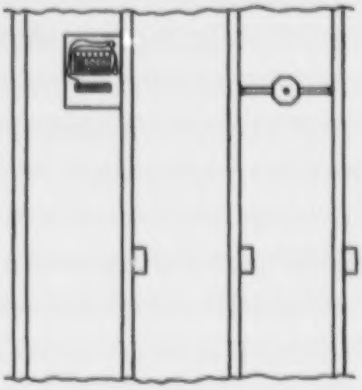
Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes.

Note: See instructor for location.

Figure 1



☐ 3. Remove a 1/2-inch knockout from panel.

☐ 4. Install cable connector.

☐ 5. Plug cord into portable GFCI.

☐ 6. Bore holes for cable.

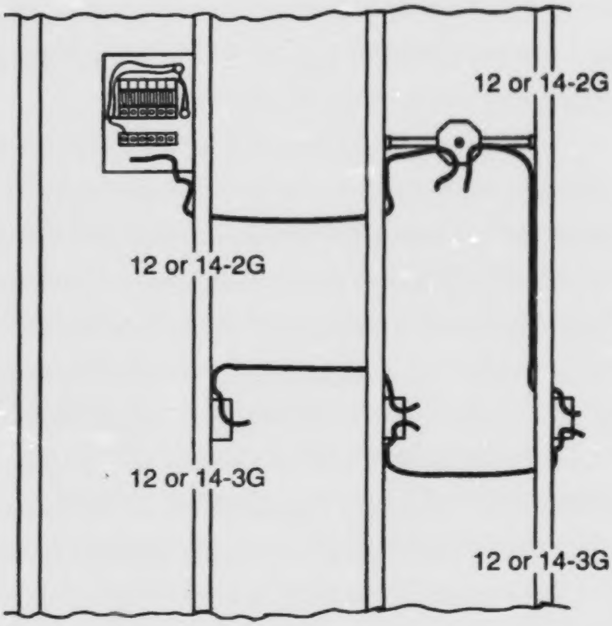
Note: Holes should be drilled as close to the center (front and back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box, depending on which route is the closest.

Caution: Be sure to hold the drill securely. A loose grip can cause an accident.

☐ 7. Run cable.

Note: Leave at least 8 inches extending past the surface of the device and the lighting outlet boxes, and enough to reach the top of the panel, plus half of the width.

Figure 2



☐ 8. Staple cable within 12 inches of all metallic boxes; 8 inches of all nonmetallic boxes.

Note: **Refer to *NEC*, Art. 334.30.**

☐ 9. Secure all cable clamps and connectors.

Caution: Tighten clamps and connectors only until the cable will not slip in the box; overtightening can cause an electrical short.

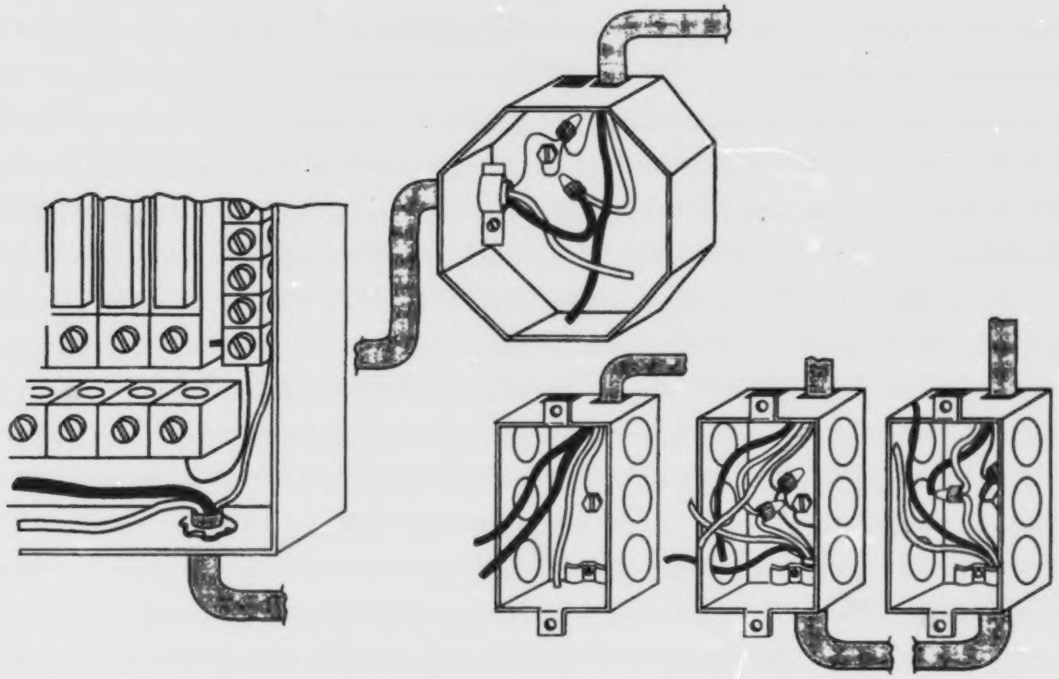
☐ 10. Strip cable insulation to within 1/4 inch of its point of entry.

Caution: Extreme care should always be sued in operations involving the knife; a cut hand can cause pain and lost work time.

☐ 11. Connect all grounding conductors.

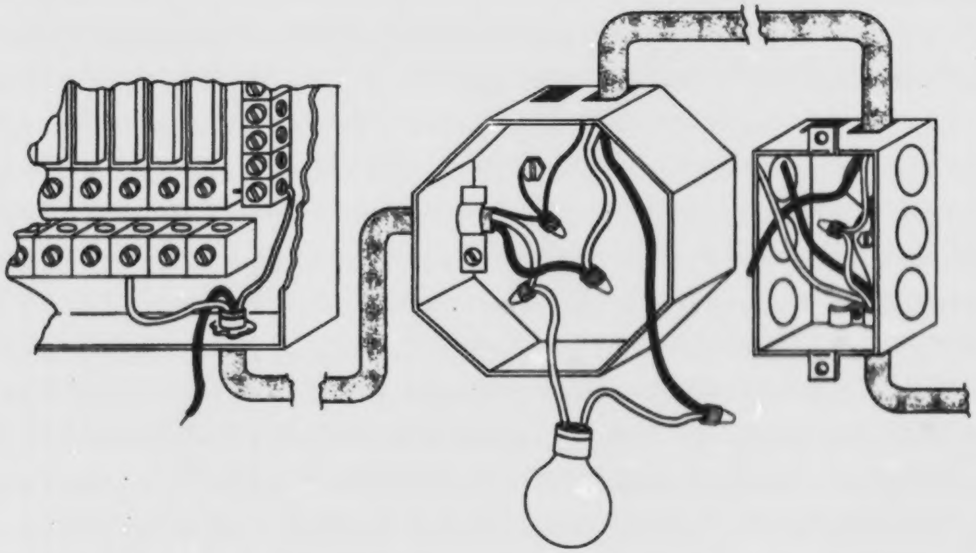
Note: Always leave enough conductor to make removal and reconnection easy. Notice the extra bend at the panel.

Figure 3



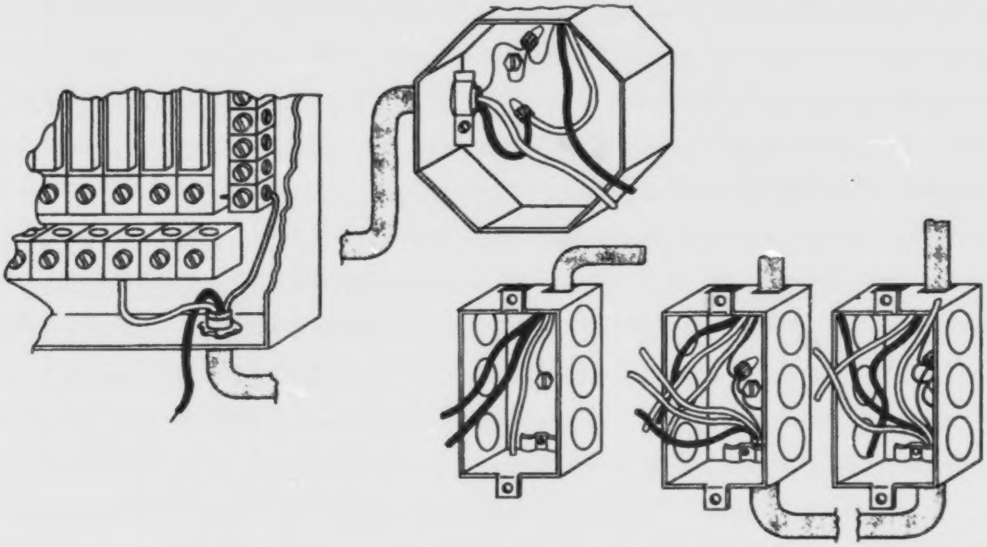
☐ 12. Connect all neutral conductors.

Figure 4



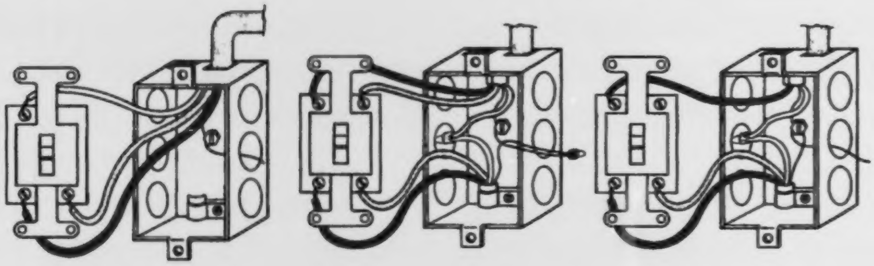
☐ 13. Connect switch legs through the system.

Figure 5



☐ 14. Install switches.

Figure 6

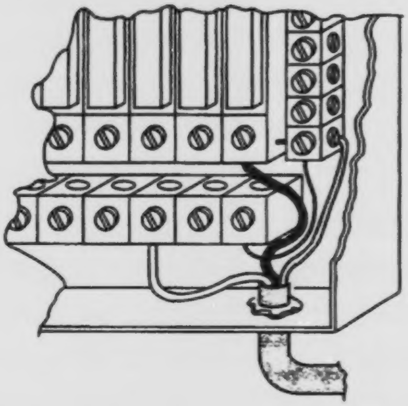


☐ 15. Connect switch leg to socket.

☐ 16. Connect ungrounded conductor to appropriate overcurrent protective device.

> **Caution**: Be sure that the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.

Figure 7



☐ 17. Turn on breaker.

> **Caution**: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 18. Change the position of the switches in alternating movements.

Note: Be sure that you can turn the light on or off from either switch, as well as on at one and off at the other.

☐ 19. Have instructor evaluate this project.

☐ 20. Turn breaker off.

☐ 21. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 4

Focus Assignment—Identify Environments and Structures Requiring Electrical Wiring Installations

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed assignment	______
• Prepared for class discussion	______

Basic Skills

Reading Writing

Introduction

As an electrician, you will be required to work in many environments and wire different types of structures. Each environment or structure may require a particular type of wiring method, or you may have an option of choosing between various wiring methods.

Directions

Make a list of environments or structures you might be required to wire as an electrician. Be prepared to discuss your list in class. The *NEC* may be a good source of information. Examples: Schools, Gas Stations

Objective 5

Assignment Sheet 1—Reference the *National Electrical Code* to Identify Uses of Wiring Methods

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• All ten methods referenced	______
• Ten of ten use descriptions accurate per assignment sheet answers	______
• Ten of ten *Code* locations accurate per assignment sheet answers	______

Basic Skills

Reading Writing

Directions

Using the *National Electrical Code*, list the permitted and not permitted uses for the following wiring methods and the specific locations where they are found in the *Code*.

a. Flexible metal conduit: ______________________________

b. Electrical metallic tubing: ______________________

c. Rigid metal conduit: ______________________

d. Liquidtight flexible metal conduit: ____________________

e. Nonmetallic-sheathed cable: ____________________

f. Electrical nonmetallic tubing: ______

g. Intermediate metal conduit: ______

h. Metal-clad cable:

i. Concealed knob-and-tube wiring:

j. Surface metal raceways:

Objective 6

Job Sheet 1—Install a Set-Screw Conduit Fitting

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 1/2-inch (16) set-screw fitting, either a connector or coupling
- 1/2-inch (16) conduit
- Screwdriver
- Safety glasses

Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Check conduit to see if it is reamed and has a square-cut end.

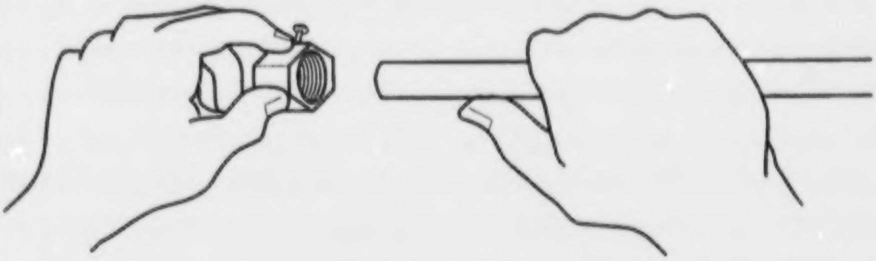
☐ 4. Pick up connector.

Note: Hold the connector in the most skillful of your hands. For example, a right-handed person should hold it in the right hand.

☐ 5. Pick up conduit with other hand.

☐ 6. Slide connector onto conduit until it bottoms.

Figure 1

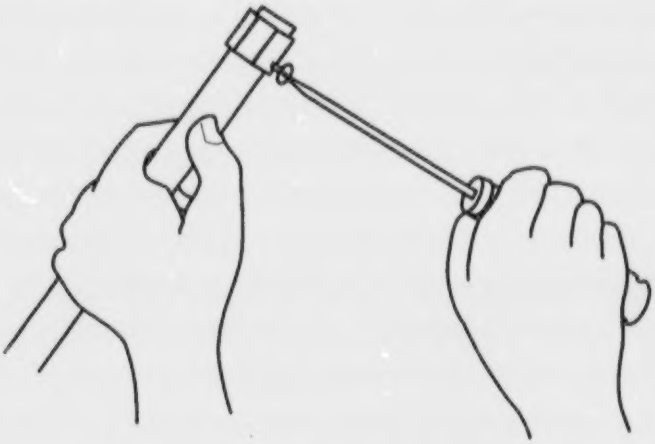


☐ 7. Secure screw with screwdriver.

Caution: Keep hand holding conduit in position away from the connector to avoid getting jabbed if the screwdriver should slip. Do not over tighten the set screw.

Note: During this operation the least skillful of your hands should be involved only in the holding of the conduit after Step 4. This nonshifting approach should save time by saving hand movement.

Figure 2



☐ 8. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 7

Job Sheet 2—Install a Compression-Type Conduit Fitting

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 1/2-inch (16) compression-type fitting, either a connector or coupling
- 1/2-inch (16) conduit
- Two pairs of groove-joint pliers or two adjustable wrenches, or one wrench and one pair of pliers
- Safety glasses

Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Check conduit to see if it is reamed and has straight even ends.

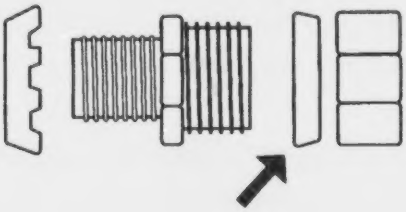
☐ 4. Pick up connector.

Note: Hold the connector in the least skillful hand, and use the most skillful hand for the next two operations to avoid handshifting.

☐ 6. Loosen compression nut.

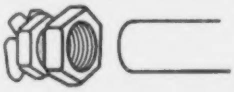
Note: Do not completely remove the nut. Look inside to ensure that the compression ring is inside the fitting. See Figure 1

Figure 1



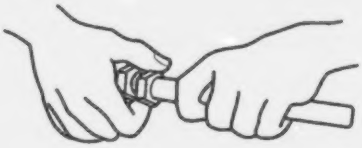
☐ 6. Slide fitting onto conduit.

Figure 2



☐ 7. Tighten compression nut by hand.

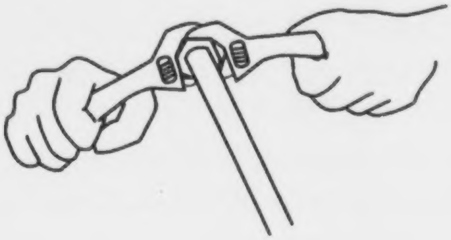
Figure 3



☐ 8. Tighten fitting with pliers or adjustable wrenches

Caution: Overtightening the smaller trade-size fitting can cause threads to strip or nuts to crack.

Figure 4



☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 8

Job Sheet 3—Prepare MC Cable For Termination

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- MC cable (approximately 24" long)
- MC cable connector
- MC cable cutting tool
- One flathead screwdriver
- Safety glasses
- Tape measure
- Anti-short bushing
- Hacksaw

Procedure

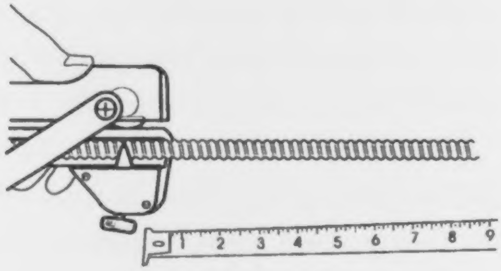
With Cable Cutter

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

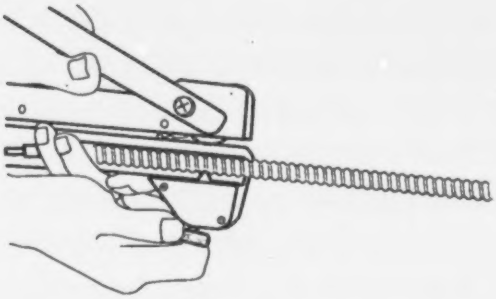
☐ 3. Place the cable into the cutter so the center of the crank is approximately 8" from the end of the cable.

Figure 1



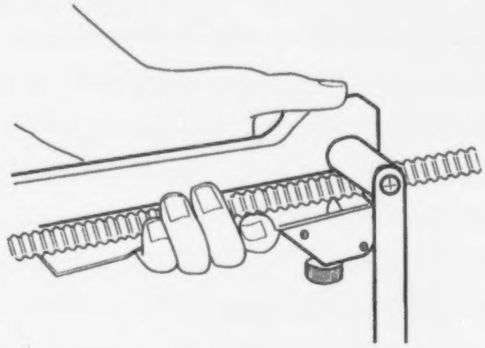
☐ 4. Tighten the thumbscrew on the bottom of the cable cutter tool by turning it clockwise.

Figure 2



☐ 5. Squeeze the handle on the cutter by applying pressure with the thumb.

Figure 3



☐ 6. Rotate the crank clockwise while squeezing the handle until no friction is felt on the crank.

Figure 4

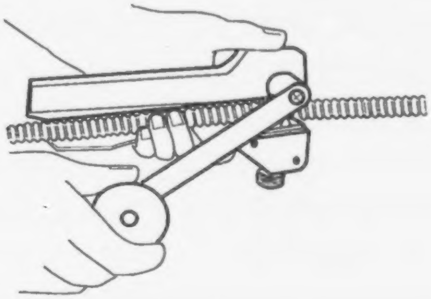


Figure 5

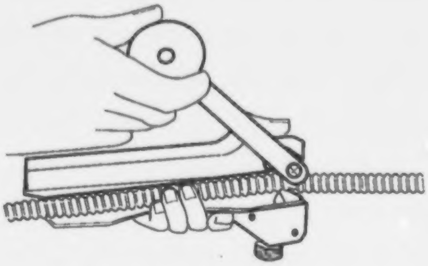
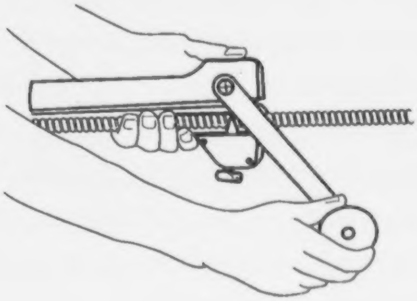
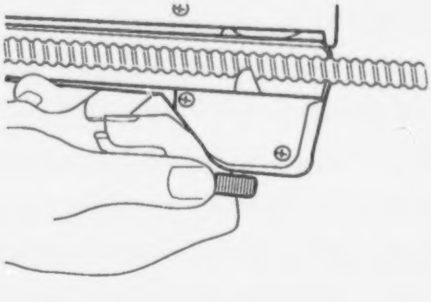


Figure 6



☐ 7. Loosen the thumbscrew on the cutting tool by turning it counterclockwise.

Figure 7



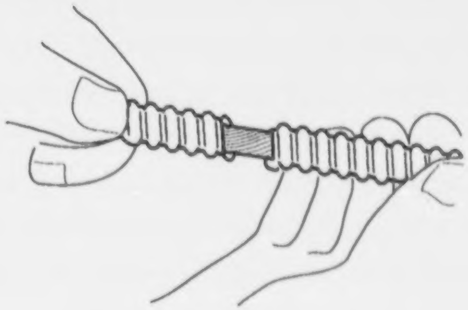
☐ 8. Remove the cable from the tool.

Caution: The two cut ends are extremely sharp. Observe proper safety precautions.

☐ 9. After twisting the end that has been cut, carefully pull the cut metallic armor off of the insulated wires.

Note: It may be necessary to slightly bend the cable prior to twisting, to completely break the metal corrugate in two.

Figure 8



☐ 10. Have the instructor check your work.

☐ 11. Clean work area, and return equipment and materials to proper storage.

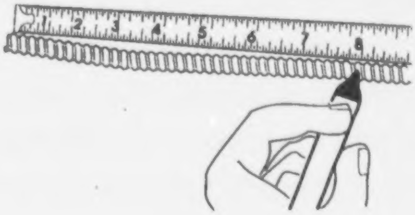
Procedure

With Hacksaw

☐ 1. Put on safety glasses.

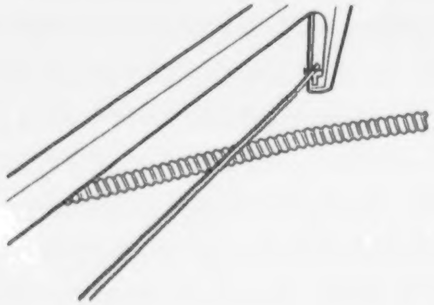
☐ 2. From the end of the cable, measure back approximately 8″.

Figure 9



☐ 3. Place the hacksaw on top of the cable at an angle close to perpendicular to one of the ridges of the metal armor.

Figure 10



☐ 4. Saw partially through the ridge of the armor.

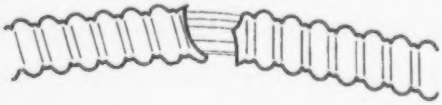
Note: Cutting too deep could cause damage to the wires inside the cable.

☐ 5. Twist the end that has been cut until the armor breaks free from the cable.

Caution: The two cut ends are extremely sharp. Observe proper safety precautions.

☐ 6. Carefully pull the armor off the insulated wires.

Figure 11



☐ 10. Have the instructor check your work.

☐ 11. Clean work area, and return equipment and materials to proper storage.

Procedure

Putting a box connector on the cable

☐ 1. Insert plastic anti short bushing between the metal armor and the wires in the cable.

Figure 12

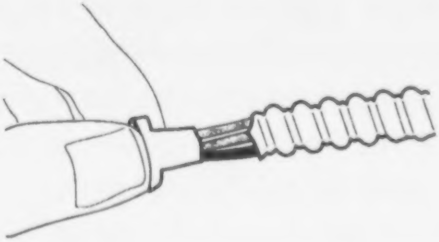
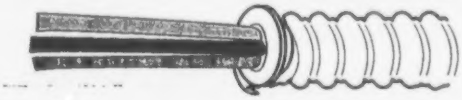
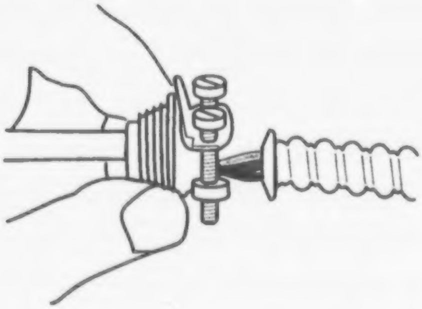


Figure 13



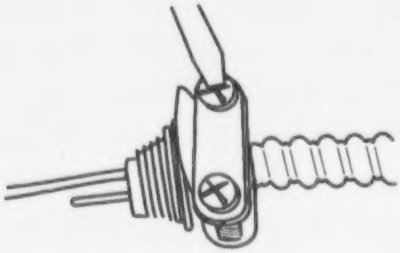
☐ 2. Slide connector over wires and onto the metal armor.

Figure 14



☐ 3. Tighten screw on connector.

Figure 15



☐ 10. Have the instructor check your work.

☐ 11. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 9

Job Sheet 4—Install a Connector Onto Liquidtight Flexible Metallic Conduit (Sealtite)

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 1/2″ (16) Sealtite (Approximately 6″ Long)
- 1/2″ (16) Sealtite straight connector
- Hacksaw
- Two pair of adjustable or channel lock wrenches
- Safety glasses

Procedure

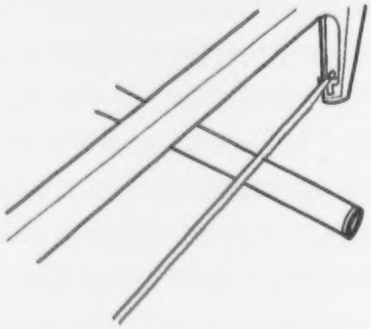
☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Measure length of sealtite.

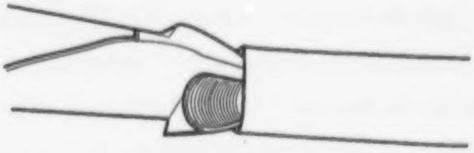
☐ 4. Cut sealtite to length using hacksaw.

Figure 1



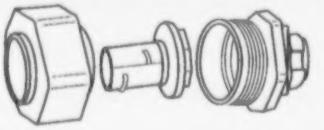
☐ 5. Ream inside of sealtite to remove rough edges.

Figure 2



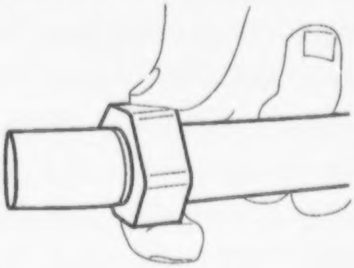
☐ 6. Unscrew the collar from the connector assembly so you will have three separate pieces: the collar, the metal throat, and the body.

Figure 3



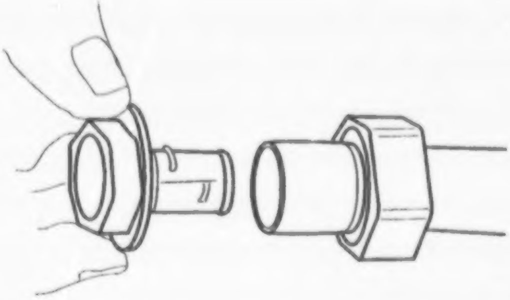
☐ 7. Slide collar onto sealtite.

Figure 4



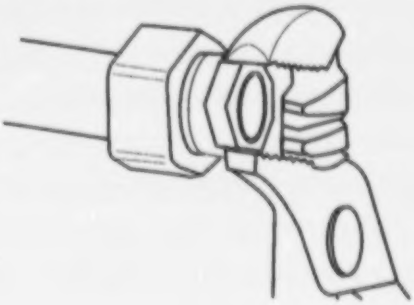
☐ 8. Screw middle throat clockwise into the end of the sealtite.

Figure 5



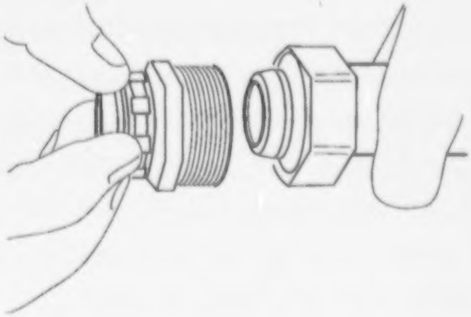
☐ 9. Tighten the throat onto the sealtite with adjustable wrench.

Figure 6



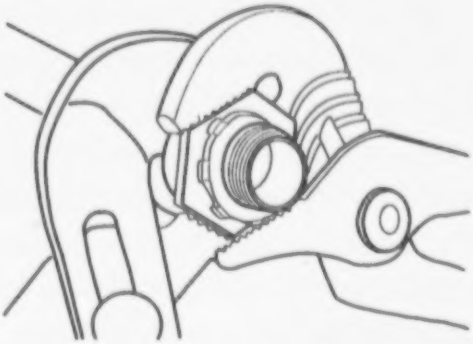
☐ 10. Place the body over the end of the sealtite and match the threads of the collar with the body threads and start turning the collar clockwise onto the body.

Figure 7



☐ 11. Using two adjustable wrenches, completely tighten the assembly.

Figure 8



☐ 12. Have the instructor check your work.

☐ 13. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ____________________

____

____

Objective 10

Job Sheet 5—Install a Connector onto Rigid Nonmetallic Conduit

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 1/2″ (16) PVC (approximately 12″ inches long)
- 1/2″ (16) PVC connector
- Hacksaw
- PVC solvent cement
- Rag or Towel
- Safety glasses

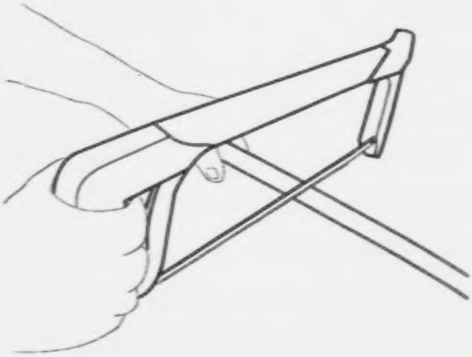
Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Cut length of PVC using hacksaw

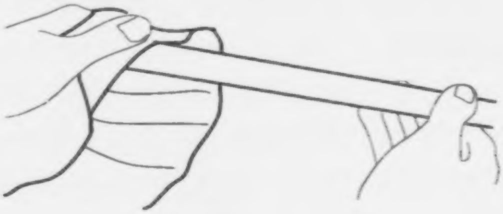
Figure 1



☐ 4. Ream conduit.

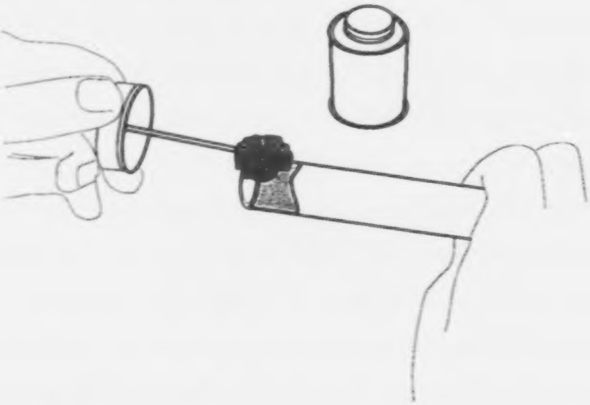
☐ 5. Use towel to wipe conduit clean and dry.

Figure 2



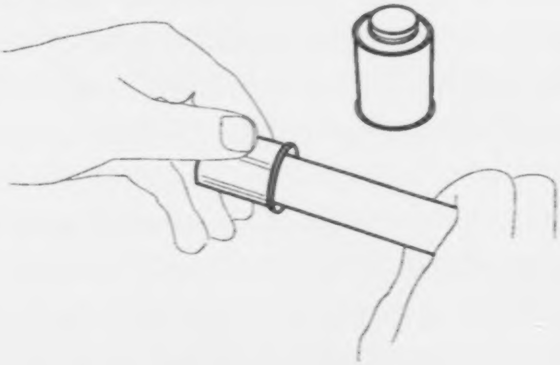
☐ 6. Apply a coat of cement with application brush around the end of the conduit wide enough for the connector socket.

Figure 3



☐ 7. Push conduit and fittings together and rotate a half turn to ensure even distribution of cement.

Figure 4



☐ 8. Have the instructor check your work.

☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

1140

Objective 12

Focus Assignment 1—Report on an Electrical Fire

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment complete	______
• Prepared for class discussion	______

Basic Skills

Reading Writing Oral Communication

Introduction

Every year, thousands of fires are started because of faulty wiring or wiring methods. Faulty wiring methods may include using the wrong size conductor, or using a conductor not rated for the selected application.

Directions

Use the library, internet, newspapers, fire department, or any other source to write a report about an electrical fire in a residence or commercial building. The report should include the following information:

- Date of the fire
- Cause of the fire
- Estimated loss of property value
- Injuries or casualties related to the fire
- Number of electrical fires that have occurred within the last year in your city or county

Conclude your report by stating in your own words, the possible preventive measures that could have been utilized to prevent the fire. Be prepared to report your findings to the class.

Note: Check with your instructor on the length of the assignment.

Objective 13

Assignment Sheet 1—List Conductors in Order, By Size

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• Minimum of twenty-five of twenty-nine answers correct per Answers to Assignment Sheet 1	______

Basic Skills

Reading Writing

Directions

Complete this assignment sheet utilizing the *National Electrical Code*. Using the blanks provided, write the following in order from the smallest to the largest wire.

#16 AWG
#250 KCMIL
#10 AWG
#1500 KCMIL
#1 AWG
#1/0 AWG
#300 KCMIL
#1000 KCMIL
#2/0 AWG
#600 KCMIL
#6 AWG
#2000 KCMIL
#3/0 AWG
#1750 KCMIL
#12 AWG
#2 AWG
#500 KCMIL
#400 KCMIL
#3 AWG
#14 AWG
#350 KCMIL
#4 AWG
#800 KCMIL
#900 KCMIL
#18 AWG
#1250 KCMIL
#8 AWG
#700 KCMIL
#4/0 AWG

a. ______________
b. ______________
c. ______________
d. ______________
e. ______________
f. ______________
g. ______________
h. ______________
i. ______________
j. ______________
k. ______________
l. ______________
m. ______________
n. ______________
o. ______________
p. ______________
q. ______________
r. ______________
s. ______________
t. ______________
u. ______________
v. ______________
w. ______________
x. ______________
y. ______________
z. ______________
aa. ______________
bb. ______________
cc. ______________

Objective 14

Assignment Sheet 2—Calculate Ampacity of Conductors, Given Insulation and Conductor Type

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• Minimum of nine of ten answers correct per answers to assignment sheet 2	______

Basic Skills

Reading Writing

Directions

Use the *National Electrical Code* Table 310.16 to list the ampacity of the following conductors, given the type of insulation and conductor. Write your answers in the space provided on the right side of the table.

Wire Size/CU* or AL**	Insulation Type	Conductor Ampacity
a. #6 AWG CU*	THHN	______
b. #2 AWG CU*	TW	______
c. #4/0 AWG AL**	RHW-2	______
d. #750 KCMIL CU*	THWN	______
e. #12 AWG CU*	UF	______
f. #8 AWG CU*	NM cable	______
g. #16 AWG CU*	XHHW, in dry location	______
h. #500 KCMIL AL**	THHN	______
i. #2000 KCMIL CU*	ZW	______
j. #1 AWG CU*	THWN-2	______

* = Copper
** = Aluminum

Objective 15

Assignment Sheet 3—Calculate Corrected Ampacity of Conductors

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• Minimum of four of five answers correct per Answers to Assignment Sheet 3	______

Basic Skills

Reading Writing Mathematics

Directions

Use the *National Electrical Code* Table 310.16 to list the ampacity of the following conductors. Then multiply that ampacity by the ambient temperature correction factor located at the bottom of Table 310.16 to calculate the corrected ampacity. Show your computations by filling in the chart with the correct figures.

Wire Size and Type	Ambient Temperature	Conductor Ampacity		Ambient temperature		Corrected Ampacity
Example; #6 AWG THHN CU*	**98° F**	**75**	**X**	**.91**	**=**	**68.25**
a. #2 AWG TW AL**	42° C		X		=	
b. #12 AWG THHN CU*	86° F		X		=	
c. #1250 KCMIL TW CU*	47° C		X		=	
d. 750 KCMIL RH AL **	73° F		X		=	
e. #2/0 AWG XHHW CU* (Dry location)	115° F		X		=	

* = Copper
** = Aluminum

Objective 16

Assignment Sheet 4—Select Conductors for Various Ampacities and Temperatures

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• Minimum of ten of eleven answers correct per Answers to Assignment Sheet 4	______

Basic Skills

Reading Writing

Introduction

The electrical worker must be able to select proper conductors for various ampacities and temperatures. This skill requires that the technician be able to locate and read *National Electrical Code* tables.

Directions

Select conductors for various ampacities and temperatures. Use the *National Electrical Code*, Table 310.16 for not more than three conductors in a raceway. Use the temperature rating column that is the same or the next higher rating than the required temperature, then select the size conductor for the required or next higher ampacity. Refer only to the sizes given for copper wiring.

Examples: What wire size is required for a load of 55 amperes at 30°C? The answer is #6 AWG. This is obtained by referring to the 60°C column because the required temperature is not above 60°C. You must then check the ampacity correction factor. Since the temperature is not over 30°C you may use the amperage listed in Table 310.16 of 55 amperes for #6.

What wire size is required for a load of 25 amperes at 68° C? The answer is #10 AWG. Although the chart under the 167° F column shows that #12 AWG is acceptable for 25 amperes at this temperature the asterisk(*) indicates that you should refer to section 240.4(D) (see bottom of table). According to this section, the overcurrent protection shall not exceed 20 amperes for #12 AWG wire. Thus, you will need to use the next heavier gauge, #10 AWG, which provides overcurrent protection up to 30 amperes.

Assignment Sheet 4

Amperes	Temperature	Wire Size Per *NEC* 310.16
20	65°C	a. ____________
35	75°C	b. ____________
37	85°C	c. ____________
110	87°C	d. ____________
110	65°C	e. ____________
232	75°C	f. ____________
400	85°C	g. ____________
540	60°C	h. ____________
67	65°C	i. ____________
83	75°C	j. ____________
190	70°C	k. ____________

Objective 17

Assignment Sheet 5—Calculate Ampacity of Conductors, Given Number of Conductors in Raceway

Name ____________________ Overall Rating ________

Date ____________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• Minimum of eleven of twelve answers correct per Answers to Assignment Sheet 5	______

Basic Skills

Reading Writing

Introduction

The electrical worker must be able to calculate the ampacity of conductors, given various numbers in the raceway. This skill requires that the technician be able to locate and read the *National Electrical Code* tables.

Directions

Use the *National Electrical Code*, Table 310.15(B)(2)(a) to calculate ampacity of conductors, given various numbers in a raceway. Complete the chart below using the values given for copper wire, type THW.

THW#	Number in Raceway	Ampacity	Number in Raceway	Ampacity
8	3	a. ________	6	g. ________
10	3	b. ________	27	h. ________
4	3	c. ________	9	i. ________
00	3	d. ________	8	j. ________
250 kcmil	3	e. ________	8	k. ________
3	3	f. ________	17	l. ________

Objective 18

Assignment Sheet 6—Calculate Ampacity and Conductor Sizes for Specific Types of Loads

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria **Rating**

- Assignment answers complete ______

Part 1
- Minimum of two of three answers correct per Answers to Assignment Sheet 6 ______

Part 2
- Minimum of four of five answers correct per Answers to Assignment Sheet 6 ______

Basic Skills

Reading Writing

Introduction

The electrical worker must be able to calculate ampacity and conductor size for various types of loads. This skill requires that the technician be able to locate and read the *National Electrical Code* tables.

Directions

Use the *National Electrical Code* Article 424.3(B), Table 430.22(E), and Table 310.16 to calculate ampacities and copper THHN conductors for the specific types of loads listed below.

Part 1

Full-Load Amperes	% Amperage	Fixed Electric Space Heater Amperes	Size of THHN Conductor
a. 27	________	________	________
b. 65	________	________	________
c. 77	________	________	________

Assignment Sheet 6

Part 2

Single Motor Load Amperes	Type of Motor	% Amperage	Full Load Motor Amperes	Size of THHN Conductor
a. 43	Elevator motor, continuous rated	______	______	______
b. 90	Varying duty, 30-60 minute rated	______	______	______
c. 110	Pump motor, 5 minute rated	______	______	______
d. 86	Valve motor, 15 minute rated	______	______	______
e. 27	Short-time duty Metal roll, 30-60 minute rated	______	______	______

Objective 19

Assignment Sheet 7—Select Cords for Various Applications

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• All four answers correct per Answers to Assignment Sheet 7	______

Basic Skills

Reading Writing

Introduction

The electrical worker must be able to select cords based on ampacity and usage conditions.

Directions

Using Tables 400.4 and 400.5 in the *NEC*, select the proper cord type letter and conductor size for the various conditions described below.

Note: Type letter blanks may have more than one answer

Trade Name of Cord	Type	Size
a. Two-conductor lamp cord; 28 amps	__________	__________
b. Two-conductor vacuum cleaner cord in oil environment; load 12 amps	__________	__________
c. Three-conductor range, dryer cable load 23 amps	__________	__________
d. Two-conductor heater cord; load 18 amps	__________	__________

Objective 20

Assignment Sheet 8—Select Proper Types of Insulation

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
Part 1 • A minimum of four of five answers correct per Answers to Assignment Sheet 8	______
Part 2 • A minimum of thirteen of fifteen answers correct per Answers to Assignment Sheet 8	______

Basic Skills

Reading Writing

Introduction

The electrical worker must be able to select insulation according to its intended use.

Directions

Part 1

Using Table 310.13 in the *National Electrical Code*, select proper insulation types for each of the following situations. Several insulation types may apply.

a. Boiler room where there is high humidity and high heat

____

b. Machine shop where there is cutting oil in use

____

c. Computer room with normal heat and humidity

____

d. Car wash with normal temperatures and high humidity

____

e. Commercial kitchen with high temperature and normal humidity

____

Assignment Sheet 8

Directions

Part 2

Using the *National Electrical Code*, Table 310.13 to find the maximum operating temperature rating in degrees centigrade and degrees Fahrenheit for each of the following insulation types, under normal uses.

Type	°C	°F
a. TFE		
b. TW		
c. THW (dry and wet)		
d. THHN		
e. MTW (wet location)		
f. RHH		
g. THWN		
h. XHHW-2		
i. ZW (dry location, special applications)		
j. XHHW (wet location)		
k. SA (special applications)		
l. MI (dry and wet location)		
m. USE		
n. PFA (dry and wet location)		
o. THHW (wet location)		

Objective 21

Job Sheet 1—Install Cord on Utilization Equipment

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Cord connector
- Wire nuts
- Small fixed appliance
- Safety glasses
- Appropriate appliance cord

Note: Cord must be acceptable to the *NEC* and local code enforcing agent.

Procedure

☐ 1. Gather tools and equipment and put on safety glasses.

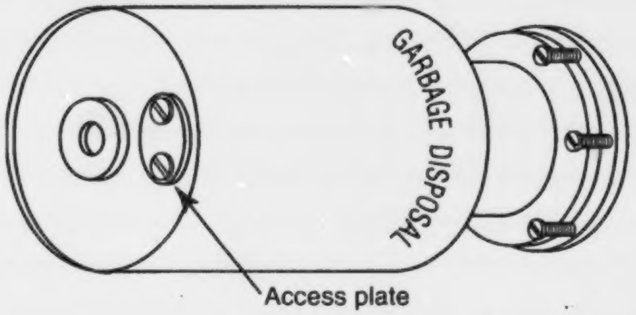
☐ 2. Locate appliance manufacturer's specification plate.

☐ 3. Compare appliance specifications to cord selected.

Note: Be sure that the cord will reach the outlet you plan on using.

☐ 4. Remove access plate from appliance.

Figure 1



☐ 5. Install cord connector.

☐ 6. Connect cord conductors to appropriate appliance terminals or conductors.

☐ 7. Adjust cord inside unit.

Note: Make sure that all conductors are free moving and not cramped.

☐ 8. Tighten cord connector.

☐ 9. Replace access plate.

Note: If an equipment grounding terminal is not provided inside the unit termination space, you can add a grounding terminal.

☐ 10. Plug unit into appropriate receptacle.

Note: Be sure to plug it into the switched receptacle

☐ 11. Test appliance for correct operation.

Note: If installing cord on a garbage disposal, run water into the disposal as you test it.

☐ 12. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 22

Job Sheet 2—Use a Fish Tape to Install Wire in Conduit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- 60 feet of conduit
- Steel fish tape, 100 or 200 feet long
- 500 feet of #10 THHN wire
- Pouch tools
- Electrician's knife
- Wire-pulling compound

Procedure

Note: Work in teams of three or more.

☐ 1. Cut six 70-foot pieces of #10 THHN.

☐ 2. Lay out wire at feed-in end of conduit run, straight enough to be installed without kinking or becoming tangled.

☐ 3. Push fish tape into opposite end on conduit run.

Note: If it is difficult to push the tape around the last 90-degree bend, grip the fish tape with lineman's pliers about 1 or 2 inches from the end and push; or while pushing on fish tape, have someone tap on conduit near the 90-degree bend where the difficulty seems to be.

☐ 4. Skin back about 5 inches of insulation on each wire at fish-tape-connection end.

5. Attach wires to fish-tape eye.

   ☐ • Squeeze bent wires, making joint the smallest size practical.

   ☐ • Apply tape tightly from conductor toward fish tape.

   Note: Taping tightly leaves the tape with no leading edges to make pulling more difficult.

☐ 6. Lubricate the connection.

☐ 7. Pull fish tape very slowly at first to get the connection into the conduit.

Note: The feed-in person can help by pushing slightly on conductors. When pulling fish tape, exert a smooth steady pull; do not jerk.

☐ 8. Pull until conductor is through conduit at appropriate length.

Note: Have instructor evaluate your work

☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 23

Job Sheet 3—Prepare an Aluminum Conductor for Termination

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Electrician's knife
- Wire brush
- Antioxidant (oxiban or equivalent)
- #2 single-lug terminal, copper or aluminum

Procedure

☐ 1. Remove 3/4 inch of insulation from conductor with knife.

Note: Do not circle the conductor with the knife. This usually nicks the wire strands and reduces their strength and conducting capacity.

☐ 2. Remove any oxide coating with wire brush.

Note: Oxide coating is dark, dull coating. It is important to remove it because aluminum oxidizes rapidly.

☐ 3. Apply antioxidant to conductor.

☐ 4. Insert conductor in lug and tighten per manufacturer's torque specifications.

☐ 5. Allow several minutes to elapse and then retighten.

Note: The strands will settle into place making a second tightening necessary.

☐ 6. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 24

Job Sheet 4—Splice Solid Conductors Using a Wire Nut

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

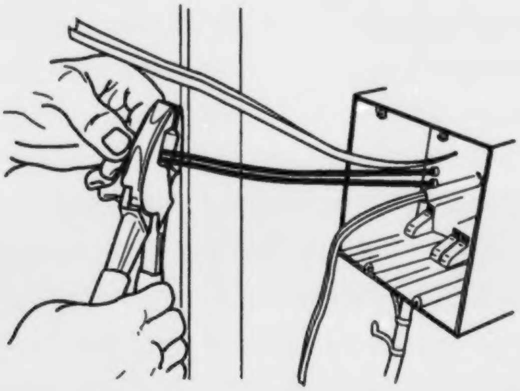
- 3 pieces of solid #14 or #12 AWG
- 1 red wing nut
- Wire strippers
- Lineman's pliers
- Safety glasses

Procedure

☐ 1. Gather tools and equipment and put on safety glasses.

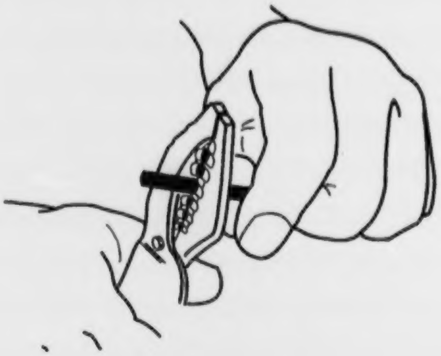
☐ 2. Cut off the three wires to the same length.

Figure 1



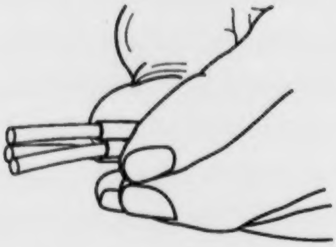
☐ 3. Strip wires approximately 1" from end with wire strippers

Figure 2



☐ 4. Hold wires so that ends are aligned.

Figure 3



☐ 5. Twist the wires clockwise together using the lineman pliers.

Figure 4

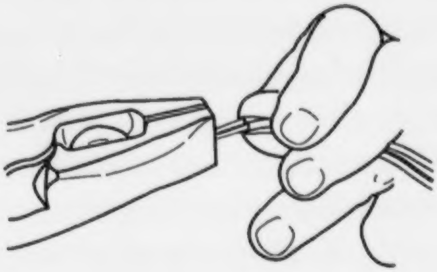
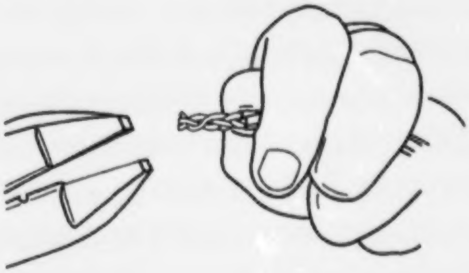


Figure 5



☐ 6. Trim the ends of the twisted wire by cutting them with the lineman pliers to remove jagged ends.

Figure 6

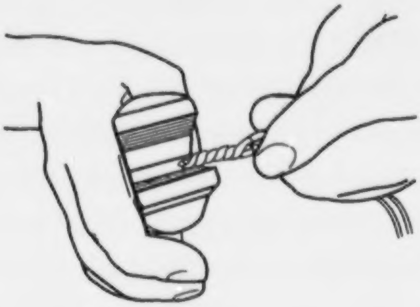
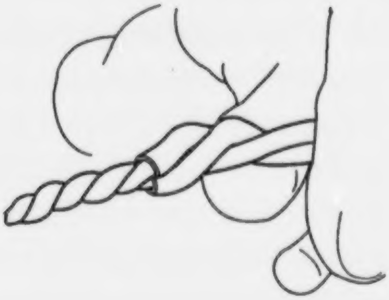


Figure 7



☐ 7. Place wire nut onto the end of the wires and screw on clockwise as tight as possible with fingers.

Figure 8

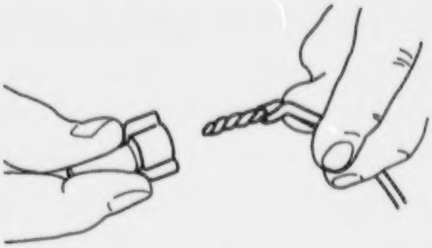
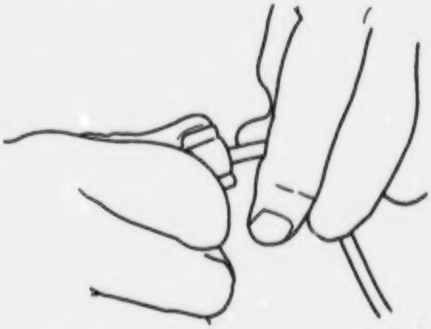


Figure 9



☐ 8. Have instructor check your work.

☐ 9. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 12

Focus Assignment 1—List Licensing Requirements for Low Voltage Wiring Systems

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• Prepared for class discussion	______

Basic Skills

Reading Writing Employability

Introduction

In this unit you will be learning about a variety of low voltage systems. Individual cities and states have varying requirements for licensing low voltage technicians. There may even be separate requirements for different systems. Example: Licensing requirements for installing security systems may differ from those required for fiber optics.

Directions

Contact the authority having jurisdiction in your city, county, or state for information on licensing requirements for low voltage related trades. List requirements in the space provided and be prepared to discuss your findings in class.

Focus Assignment Sheet

Objective 13

Assignment Sheet 1—Draw a Wiring Diagram Indicating the Proper Connection for Bell Circuit Equipment

Name ______________________ Overall Rating __________

Date ______________________

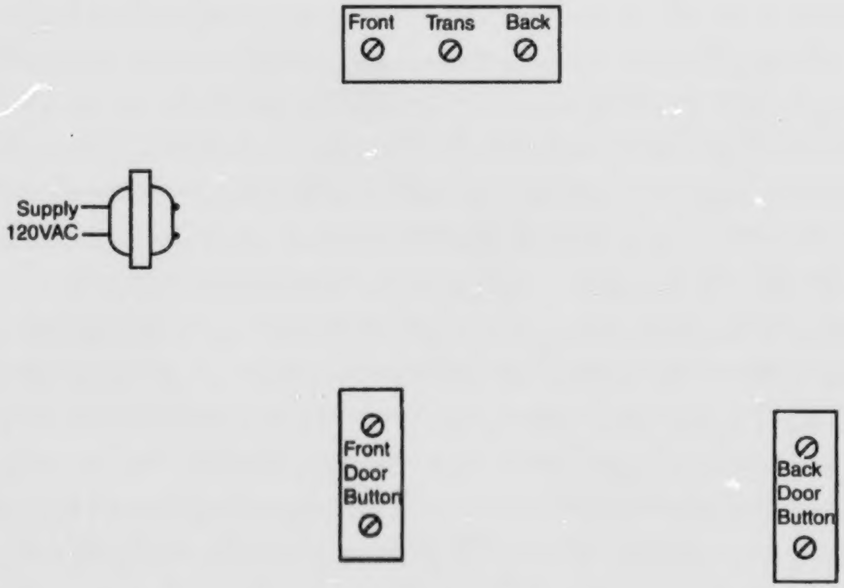
Evaluation Criteria	**Rating**
• All connections indicated	______
• Correct symbols used	______
• Circuit wiring correct configuration per answer to assignment sheet	______

Basic Skills

Reading Writing

Directions

Draw a wiring diagram indicating the proper connection for the bell circuit equipment below. Make connections so that the bell announces the rear door and the front door.


Front
Trans
Back
Supply
120VAC
Front Door Button
Back Door Button

Objective 14

Assignment Sheet 2—Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors

Name ______________________ Overall Rating __________

Date ______________________

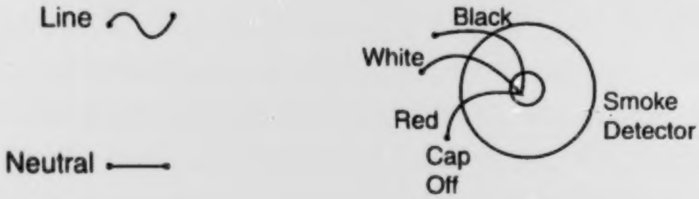
Evaluation Criteria	Rating
• All connections indicated	______
• Correct symbols used	______
• Circuit wiring correct configuration per answer to assignment sheet	______

Basic Skills

Reading   Writing

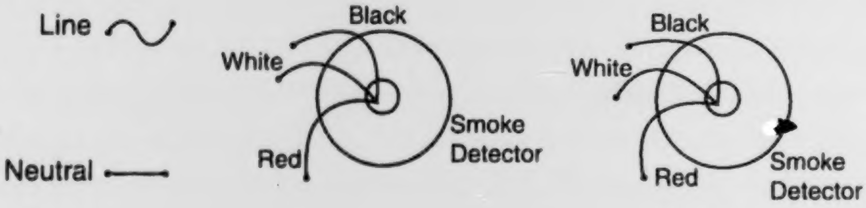
Directions

Draw a wiring diagram indicating the proper connections for a single smoke detector and two interconnecting smoke detectors.


Line
Neutral
Black
White
Red
Cap
Off
Smoke
Detector

Directions

Make connections so that both alarms operate when either test button is pressed.


Line
Neutral
Black
White
Red
Smoke
Detector
Black
White
Red
Smoke
Detector

Objective 15

Job Sheet 1—Wire a Two-Button Chime Circuit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Two door bell buttons
- 18-3 and 18-2 bell wire cables
- 16-volt transformer
- Chime with front and back call
- 12-2G or 14-2G NM cable
- Electrician's hammer
- Long-nose pliers
- Flat-blade screwdriver
- Cable staples
- 3/8-inch cable clamp
- Stud wall or shop board
- 120-volt power supply
- Pocket knife
- Wire strippers
- Wire connectors
- Octagon box and blank plate with 1/2-inch KO
- 3/4-inch #10 metal tapping screws
- Drill motor and bit or brace
- 1/2-inch or lager wood bit
- Extension cord
- Header board (short piece of 1″ x 6″ or 2″ x 4″)
- Four 16-penny nails
- Safety glasses
- GFCI

Job Sheet 1

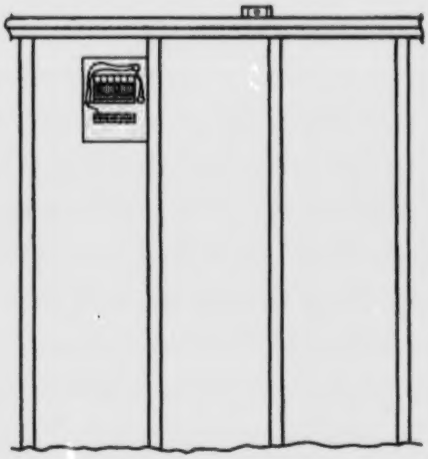
Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount box.

Note: If mounted on a wall plate this box must be above insulation. The best place to mount the transformer is a furnace closet so you can change it without going into the attic.

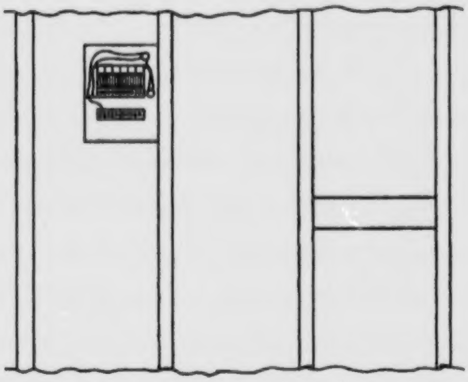
Figure 1



☐ 3. Mount header

Note: It must be mounted flush with wall surface.

Figure 2

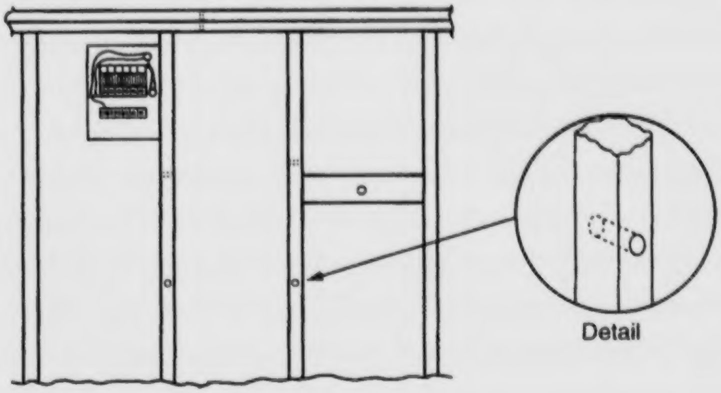


1169

☐ 4. Drill holes.

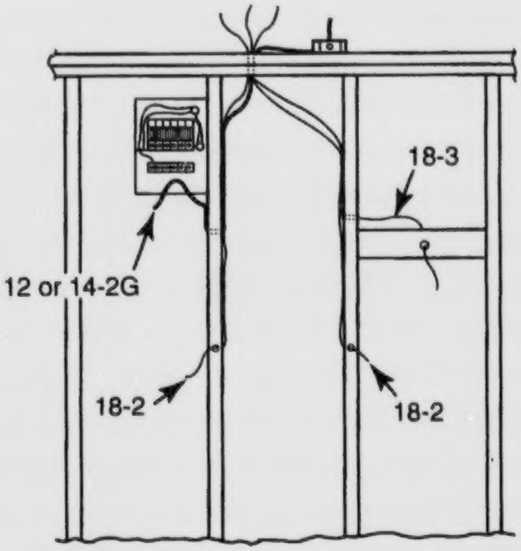
Note: On a residential rough-in, button wires are drilled through at an angle in the door opening. Use GFCI when drilling.

Figure 3



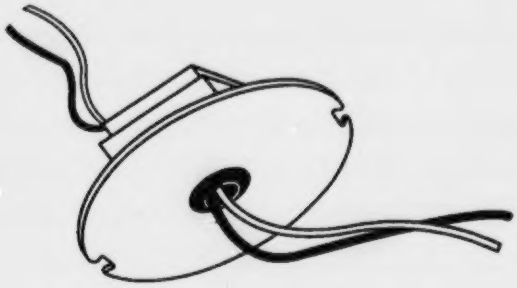
☐ 5. Run cable.

Figure 4


18-3
12 or 14-2G
18-2
18-2

☐ 6. Mount transformer to blank plate.

Figure 5

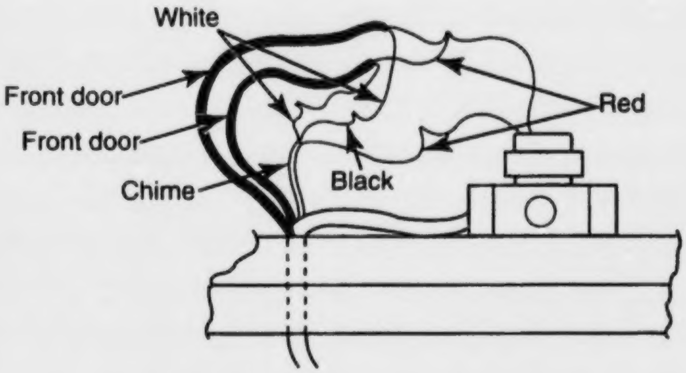


☐ 7. Connect transformer supply leads to cable from panel.

☐ 8. Mount blank plate on octagon box.

☐ 9. Make low voltage connections at transformer.

Figure 6

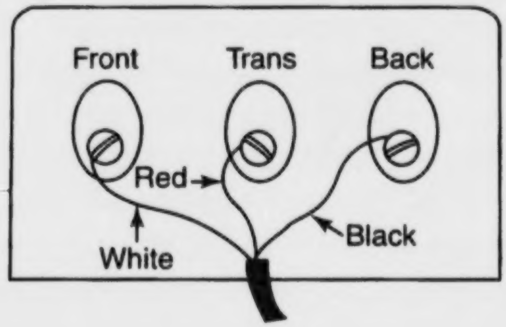

White
Front door
Front door
Chime
Black
Red

☐ 10. Mount chime on header.

Note: Put cable through opening in subbase before securing chime.

☐ 11. Connect conductors to chime.

Figure 7



☐ 12. Connect buttons.

☐ 13. Connect conductors at panel.

☐ 14. Turn on breaker.

☐ 15. Push front button.

Note: A two-tone chime should be heard.

☐ 16. Push back button.

Note: A one-tone chime should be heard.

☐ 17. Have instructor evaluate work.

☐ 18. Turn off breaker.

☐ 19. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 16

Job Sheet 2—Wire Two Interconnecting Smoke Detectors

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Two single-gang plaster rings or two regular device boxes
- 12-3G or 14-3G NM cable
- 12-2G or 14-2NM cable
- Wire connectors
- Staples
- Stud wall or shop board
- Fasteners (nails or screws) to secure boxes and hanger bar
- Two line voltage smoke detectors with or without battery back up
- Electrician's hammer
- Flat-blade screwdriver
- Lineman's pliers
- Long-nose pliers
- Knife
- Wire strippers
- Drill motor and bit or brace
- Extension cord if a drill motor is used
- 1/2-inch or larger wood bit
- Safety glasses
- Portable GFCI
- 120-volt power supply

Note: A breaker panel with one breaker is needed.

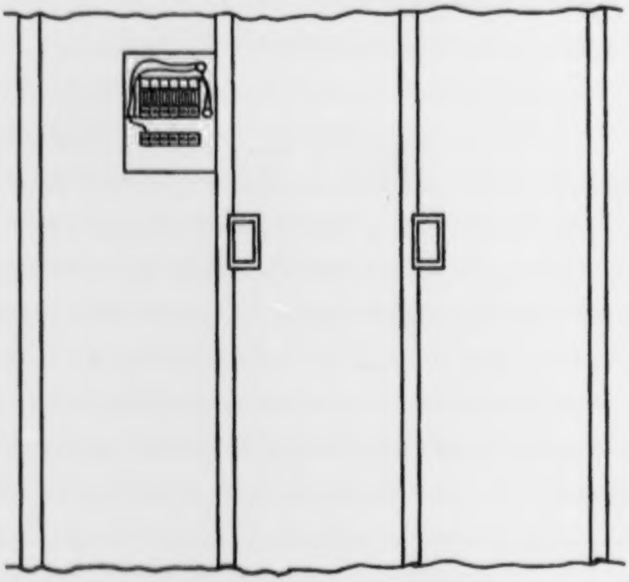
Job Sheet 2

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes

Figure 1



☐ 3. Drill holes for power cable runs.

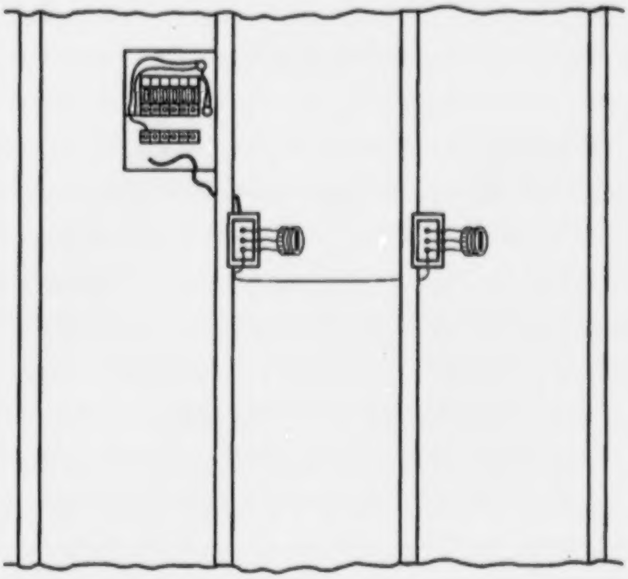
Note: Use your GFCI when drilling.

☐ 4. Run 120-volt supply cable from panel to first outlet box (12-2G or 14-2G NM.)

☐ 5. Run 120-volt cable from first box to second box (12-3G or 14-3G NM.)

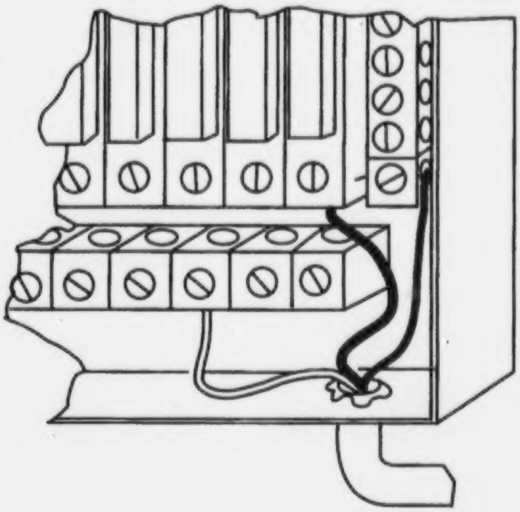
☐ 6. Make connections to smoke detector terminals or pig tails in accordance with manufacturer's instructions (Refer to Assignment Sheet 2.)

Figure 2



☐ 7. Make up panel.

Figure 3



☐ 8. Turn on breaker.

☐ 9. Test that both alarms operate when either test button is pressed.

☐ 10. Have your instructor evaluate this project.

☐ 11. Turn off breaker

☐ 12. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 10

Focus Assignment 1—Identify Overcurrent Protective Devices

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Identified overcurrent devices	______
• Assignment answers complete	______

Basic Skills

Reading Writing

Introduction

In this unit you will be studying various types of overcurrent protective devices and their ability to protect electrical equipment. You will learn the different types, brands, and styles, and which are used in specific applications.

Directions

Your instructor will provide different overcurrent devices for you to inspect and identify. With your instructor's help, write down the type of overcurrent device and at least one application you think it may be used for.

Type of Device	Application

Objective 11

Assignment Sheet 1—Calculate Conductor and Fuse Sizes

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers correct	______
• Minimum of 5 of 6 answers correct per answers to Assignment Sheet 1	______

Basic Skills

Reading Writing Mathematics

Introduction

Electricians must be able to calculate correct conductor and fuse sizes by referring to *NEC* articles and tables, and other appropriate reference materials.

Directions

Use the following steps to calculate conductor and fuse size. Refer to Article 430.22 for information on sizing single motor overcurrent devices, Tables 430-147 through 151 for calculating full load current (FLC), Table 310.16 for determining allowable ampacity, and Table 430.52 for calculating percentage of FLC, given fuse type.

Steps

1. Find the full load current (FLC) for the motor (refer to Tables 430.147 through 151).
2. Multiply the FLC of the motor by 125% (refer to article 430.22).
3. Using table 310.16, find the correct conductor size for the motor and insulation type.
4. Go to Table 430.52 and determine the percentage of FLC using the type of fuse as a guide. Multiply the FLC by the maximum percentage.
5. Using the calculation in Step 4, find the standard size overcurrent protection by referring to Article 240.6.

Example

What size THW copper conductor would be required for a 230-volt, 20 horsepower, three-phase motor? What size dual-element fuse would be required?

1. Using Table 430-150, determine that the FLC of a 20 horsepower, three-phase motor running at 230 volts is 54 amps.

2. Multiply 54 amps by the required ampacity of 125%. 1.25 X 54 = 67.5 amps.
3. Using Table 310.16, enter the column marked for THW copper conductors. Go down and see that a #6 copper conductor is good for 65 amps. Since this motor has a FLC of 67.5 amps, you must use the next larger conductor size, or a #4 copper conductor.
4. Using Table 430.52, determine that the maximum rating for a dual element fuse is 175 percent of the FLC. Multiply 175% by the FLC of 67.5 amps. 1.75 X 67.5 - 118.1 amps.
5. Using Article 240.6 as a guide, determine that the required dual element fuse size will be 125 amps since 188.1 is more than the next smaller size of 110 amps.

Directions

Using information in the *NEC* and the example as a guide, answer the following questions.

1. What size THW copper conductor would be required for a 230-volt, 40 horsepower, three-phase motor?

   ______________________ THW Copper Conductor

2. What size dual element fuse would be required for a 460-volt, 20 horsepower, three-phase motor?

   ______________________ Amp Dual Element Fuse

3. What size THHN copper conductor would be required for a 460-volt, 10 horsepower, three-phase motor? What size dual element fuse would be required?

   ______________________ THHN Copper Conductor

   ______________________ Amp Dual Element Fuse

4. What size THHN copper conductor would be required for a 208-volt, 5 horsepower, single-phase motor? What size inverse time circuit breaker?

   ______________________ THHN Copper Conductor

   ______________________ Amp Inverse Time Breaker

Objective 12

Job Sheet 1—Test Cartridge Fuses

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Eye protection
- Live disconnect
- Several fuses, both good and bad
- Voltmeter for voltage to be tested
- Gloves

Procedure

> **Caution:** Live voltages are present during this test. Observe proper safety precautions.

☐ 1. Put on eye protection.

☐ 2. Deenergize disconnect.

☐ 3. Install fuses.

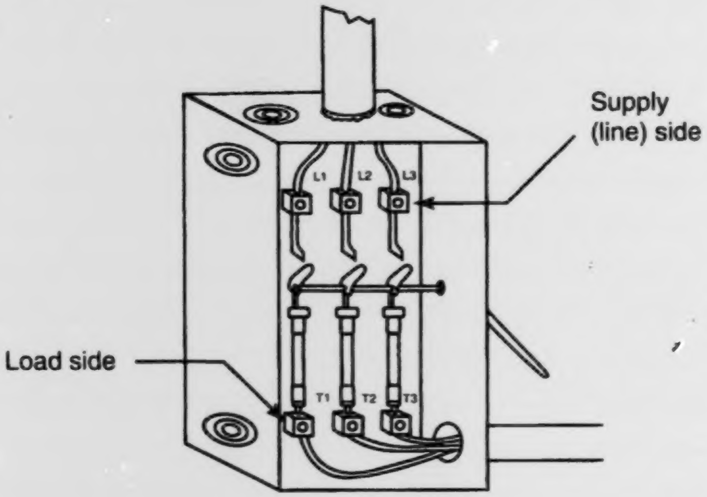
☐ 4. Energize disconnect and leave disconnect door open.

☐ 5. Set voltmeter to appropriate voltage scale.

☐ 6. Test voltage on supply side of disconnect. (Figure 1)

Note: On a 208-volt, three-phase disconnect, 208 volts should be present from L1 to L2, L1 to L3, and L2 to L3.

Figure 1



☐ 7. Place voltmeter probe #1 on L1 terminal and probe #2 on T2 terminal; voltage should be 208 volts.

☐ 8. Move probe #2 to T3 terminal; voltage should be 208 volts.

☐ 9. Move probe #1 to L2 terminal and probe #2 to T1 terminal; voltage should be 208 volts.

☐ 10. Move probe #2 to T3 terminal; voltage should be 208 volts.

☐ 11. Move probe #1 to L3 terminal and probe #2 to T1 terminal; voltage should be 208 volts.

☐ 12. Move probe #2 to T2 terminal; voltage should be 208 volts.

Note: A lower voltage or no voltage indicates a bad fuse. When meter shows low or no voltage, probe #2 will always be under the fuse that is bad.

☐ 13. Repeat Steps 2 through 12 using different fuses.

Note: Have instructor evaluate work.

☐ 14. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 10

Focus Assignment 1—Determine Cost of Load Center Construction

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Correctly identified components	______
• Accurately priced components	______

Basic Skills

Reading Writing

Introduction

The load center is the "heart" of any electrical system. It is critical to be able to identify the parts of a load center, and estimate the cost of repairing or building a load center.

Directions

a. Locate the load center that serves your facility.

b. Observe safety rules and determine the style and part number of each component.

c. Using catalogs, suppliers, or the internet, find the price of each component of the load center (load center, circuit breakers, or any other component present).

d. Submit your itemized list to your instructor.

Component	Price

Objective 11

Assignment Sheet 1—Using the *NEC*, Answer Questions Related to Load Centers

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Assignment answers complete	______
• Minimum of seven of eight answers correct per Answer to Assignment Sheet 1	______

Basic Skills

Reading Writing

Directions

Answer the following questions related to load centers. Use the *National Electrical Code*, Article 384, and state the code reference number.

Note: A load center may be considered a switchboard, panelboard, or distribution board.

a. Is it necessary to have a dedicated room for the location of load centers?

____

Code Reference ______________________

b. What code articles reference to this type of equipment?

____

Code Reference ______________________

c. A power panelboard is one having ______________ percent or fewer of its overcurrent devices protecting lighting and appliance branch circuits?

____

Code Reference ______________________

d. What is the maximum number of overcurrent devices allowed in any one lighting and appliance branch circuit panelboard?

____

Code Reference ____________________

e. May a NEMA 1 load center enclosure be installed in a wet location?

____

Code Reference ____________________

f. The rating of any one cord-and-plug-connected utilization equipment shall not exceed __________ percent of the branch-circuit ampere rating.

Code Reference ____________________

g. Is a deadfront required on a load center in a residential dwelling?

____

Code Reference ____________________

h. What is the minimum front working space required for a load center of less than 600 volts.

____

Code Reference ____________________

Objective 12

Job Sheet 1—Install a Safety Switch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- General-duty safety switch (indoor or raintight, three-pole, four-wire, three-fuse switch, 250-volt, 60 ampere rating
- Pouch tools
- Piece of #6 insulated wire, 10 feet long
- Six #10 sheet metal screws, 3/4-inch long
- Backboard and mounting screws
- Three FRNR fuses, 60 amperes
- Level
- Two EMT conduit connectors, 1-inch diameter
- Tape measure

Procedure

☐ 1. Determine exact installation location.

☐ 2. Install a mounting screw for the top mounting hole.

☐ 3. Hang switch box on the screw.

Note: The hole in the upper middle back of the housing should slip over the screw head.

☐ 4. Level the box.

☐ 5. Locate holes for the remaining two mounting screws.

☐ 6. Install the lower two mounting screws.

Note: Be sure that box is level.

☐ 7. Open 1-inch knockout holes in top and bottom of switching housing.

☐ 8. Install a 1-inch EMT connector in each knockout hole.

☐ 9. Cut six 12-inch lengths of #6 wire.

☐ 10. Strip back one end of each piece of wire about 5/8 inch.

☐ 11. Install three #6 wires through the 1-inch connector in the top of the switch housing, and connect to terminals L1, L2, and L3.

Note: Install the wires neatly, taking care to prevent the wires from rubbing against any metal edge.

☐ 12. Firmly tighten terminals, L1, L2, and L3 to manufacturer's torque specifications.

Caution: Loose connections are a chief cause of electrical problems.

☐ 13. Install three pieces of #6 wire through the 1-inch connector in the bottom of the switch housing, and connect to load terminals T1, T2, and T3.

Note: Install the wires neatly, taking care to prevent the wires from rubbing against any metal edge.

☐ 14. Firmly tighten terminals T1, T2, and T3 to manufacturer's torque specifications.

☐ 15. Determine length of ground wire by measuring from top of box to ground terminal.

☐ 16. Cut a piece of #6 wire to the measured length.

☐ 17. Strip back the lower end of the ground wire; install in the ground terminal and tighten.

☐ 18. Install ground wire through bottom hole in switch housing.

☐ 19. Form the ground wire neatly so that it will not touch any moving part of the switch.

☐ 20. Strip back upper end of ground wire; install ground wire in switch terminal and tighten.

☐ 21. Insert the three 60-amp fuses into the fuse clips.

Note: Fuse clips must fit tightly on each fuse. Have instructor evaluate your work. If installation is satisfactory, it may be used for completing Job Sheet 2.

☐ 22. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 13

Job Sheet 2—Wire a Load Center or Breaker Panel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	
• Performed all steps in procedure	______
• Cleaned work area	

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Single-phase load center, 100 amperes
- Two 2-pole breakers, 30 amperes
- Two single-pole breakers, 30 amperes
- Eight single-pole breakers, 20 amperes
- Studs or backboard for mounting panel
- Four #10 sheetmetal mounting screws, $^{3}/_{4}$ inch long
- Two pieces of #2 insulated copper wire, 30 inches each
- Piece of #2 insulated copper wire, 60 inches long
- Seven pieces of #10 insulated wire, 5 feet each (color other than green or white)
- Eight pieces of #12 insulated wire, 6 feet each (color other than green or white)
- Eight pieces of green #12 insulated wire, 6 feet each
- Eight pieces of white #12 insulated wire, 6 feet each
- Four pieces of green #10 insulated wire, 6 feet each

  Note: Length of ground wire may vary depending on location of the ground bar. Use good judgment in cutting wire lengths.
- Pouch tools
- White or gray phasing tape
- Compression-type EMT connector, 1$^{1}/_{4}$-inch diameter
- Twelve compression-type EMT connectors, $^{1}/_{2}$-inch diameter
- Compression-type EMT connector, $^{3}/_{4}$-inch diameter
- Breaker index sheet
- Piece of #4 bare wire 3 feet long for use as a grounding electrode conductor

Procedure

☐ 1. Before mounting panel, open twelve $^{1}/_{2}$-inch knockout holes, one $^{3}/_{4}$-inch knockout hole, and one 1$^{1}/_{4}$-inch knockout hole for EMT conduit.

Note: The 1$^{1}/_{4}$-inch knockout hole will generally be located in the center of the top of the panel. The $^{1}/_{2}$-inch and $^{3}/_{4}$-inch knockouts may be located in the top or bottom, or both top and bottom.

☐ 2. Install the 1/2-inch and 3/4-inch EMT connectors; tighten snugly.

☐ 3. Install the 1 1/4-inch EMT connector; tighten snugly.

☐ 4. Mount panelboard in designated location.

☐ 5. Connect one end of the #4 bare ground wire to the ground bar, allowing other end to hang from bottom of panel.

Note: Under actual installation, the lower end of the ground wire would terminate at the grounding electrode.

☐ 6. Strip back one end of each piece of insulated wire approximately 5/8 to 3/4 inch.

☐ 7. Install one piece of #2 wire through the 1 1/4-inch connector to the neutral bar connector; arrange the wire neatly to lay in back corner of the panel; then insert wire in neutral bar terminal and tighten snugly.

Note: The neutral conductor should lay in the back corner of the panel to leave adequate room for the other wires and breakers. It should also be identified by white or gray tape.

☐ 8. Install the remaining two wires through the 1 1/4-inch connector, and insert wires in the main breaker connectors.

Note: Arrange wires neatly, allowing room for the branch-circuit conductors.

☐ 9. Plug the two 2-pole breakers into the panel bus, one breaker on the right, the other on the left at the top positions.

☐ 10. Plug the two single-pole, 30 amp breakers into the panel bus, one breaker on the left, the other on the right in the top positions.

☐ 11. Plug the eight single-pole breakers into the panel bus, four breakers on the left, and four on the right in the remaining positions.

☐ 12. Install remaining wires.

  ☐ a. For the two-pole breakers, insert two #10 colored wires (other than green or white) and one #10 green wire through the 3/4-inch connector.

  Note: This method places this group of wires in the back of the panel, out of the way of neutral and circuit wires; also, it gives the technician an organized procedure for doing the work neatly.

  ☐ b. For the single-pole, 30-amp breakers, insert two #10 colored and one #10 green wire for each breaker.

  ☐ c. For the single-pole breakers, insert one #12 colored, one #12 white for neutral, and one #12 green wire for each breaker.

☐ 13. Tag or mark by number, each group of wires that goes to a specific breaker

☐ 14. Fold back out of the way all branch circuit wires inside the panel to provide clear working space inside panel.

☐ 15. Trim out panelboard.

  ☐ a. Work the green wires one at a time, arranging them against back of panel in corners and making right angle bends to the ground bar terminals.

  ☐ b. Cut, strip, and insert wires into terminals; tighten snugly.

  Note: This method places this group of wires in the back of the panel , out of the way of neutral and circuit wires; also, it gives the technician an organized procedure for doing the work neatly.

  ☐ c. Work the white neutral wires one at a time, laying the wires near the green wires in the back spaces and corners of the panel and making bends to the neutral or ground bar.

  ☐ d. Cut, strip, and insert wires into terminals; tighten snugly.

  ☐ e. Work the colored circuit wires.

    ☐ (1) Work the #10 wires one at a time to the left two-pole breaker, forming the wire to lay neatly toward the back and side of panel; make right angle bends to bring wire horizontally toward proper breaker terminal; make additional right-angle bends to bring wires outward and then into breaker.

    Note: This procedure makes it easy to trace wires, provides enough wire length to pull out and check loads with a clamp-on ammeter, and produces a neat, professional-looking job.

    ☐ (2) Work the #10 wires to the right two-pole breaker, using the procedure outlined in Step e(1).

    ☐ (3) Work the wires to the single-pole 30 amp breakers, using the procedure outlined in Step e(1).

    ☐ (4) Work the single-pole circuit wires, making neat bends and using the same procedure outlined in Step e(1).

  ☐ f. Double-check to make sure that all connections make good contact and are tightened to manufacturer's torque specifications.

☐ 16. Have instructor evaluate your work.

☐ 17. Carefully dismantle the assembly and store parts in proper place.

☐ 18. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 14

Job Sheet 3—Wire a Receptacle Circuit to a Load Center

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	
• Performed all steps in procedure	______
• Cleaned work area	

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- 1/2-inch drill motor
- 1/2-inch ship auger
- Romex staples
- 15-foot 12/2 with ground NMB
- Three plastic 1-gauge nailup device boxes
- 4-foot 10/3 with ground
- Three 15-amp 125-volt duplex receptacles
- 2- or 4-circuit load center
- One 20-amp single-pole breaker
- Two $^1/_2$-inch Romex connectors
- Four #10 x 1 sheetmetal screws
- *NEC*

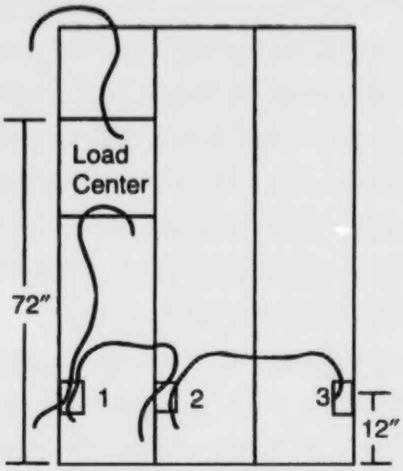
Job Sheet 3

Procedure

☐ 1. Mark and lay out boxes according to drawing. (Figure 1)

Note: Be sure to check the *NEC* for installation of NM cable.

Figure 1



☐ 2. Mount device boxes for 1/2-inch Sheetrock®.

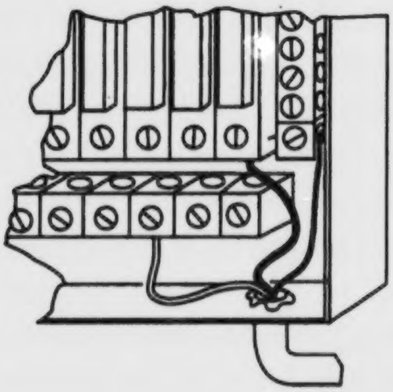
☐ 3. Mount load center for flush installation (1/2-inch Sheetrock®).

☐ 4. Drill studs according to cable layout and *NEC*.

☐ 5. Route cable through studs, and support properly.

☐ 6. Install Romex connector in bottom of load center and install cable.

Figure 2



1192

☐ 7. Strip sheath from cables in device boxes.

Note: Be sure that at least 6 inches of conductor leaves the face of the box.

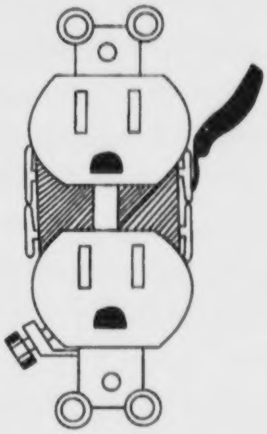
☐ 8. In boxes 1 and 2, twist grounds together and install a green wire nut, leaving enough pigtail to terminate on receptacle grounding terminal.

☐ 9. Strip $^{1}/_{2}$-inch of insulation from neutral (white) conductors and twist in a 6-inch pigtail; install a red wire nut over joint.

☐ 10. Terminate all conductors according to instructor's demonstration. (Figure 3)

Note: Methods may vary due to local codes.

Figure 3



White Neutral Conductor to White or Silver Terminal

Black Conductor to Brass or Dark Terminal

Grounding Conductor to Green or Hex-Head Terminal

☐ 11. Install Romex connector in top of load center and terminate the 10/3 with ground as the feeder conductors.

☐ 12. Double check to make sure all terminations are tight.

☐ 13. Have instructor evaluate your work.

☐ 14. Carefully dismantle the assembly and store parts in proper places.

☐ 15. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 11

Assignment Sheet 1—Determine the Number of Conductors Allowed to be Added to an Existing Conduit

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• All four answers are correct per Answers to Assignment Sheet 1	______

Basic Skills

Reading

Mathematics

Directions

Using the steps listed in Objectives 7 and 8 of the Information Sheet and the *NEC*, determine whether additional conductors may be added to a conduit or whether a new conduit is necessary. Show your calculations.

a. An existing 3/4-inch(21) electrical metallic conduit contains three #10 THW conductors; you need to add three more #10 THW conductors. Can you do so? What is the maximum number allowed?

b. A 1/2-inch(16) liquidtight flexible metal conduit contains three #10 THHN conductors. Will four more #10 THHN conductors be allowed? What is the maximum number allowed?

c. A 1$^1/_2$-inch(41) rigid metal conduit contains three I/O THW conductors. Will three #6 THHN conductors be allowed?

d. A 1-inch(27) rigid PVC (schedule 80) conduit contains three #14 THHW conductors. Will four #6 TW conductors be allowed?

Objective 12

Job Sheet 1—Install a Metallic Box with Dry-Wall Grips in a Plasterboard Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Plasterboard wall
- Box with plaster ears and dry-wall grips
  Note: Several forms of attaching devices are made for securing boxes in dry-wall plasterboard.
- Pouch tools
- 1/2-inch drill bit
- Brace or drill motor and cord
- Pencil
- Keyhole saw
- Safety glasses
- Drop cloth
- Duplex receptacle

Procedure

Note: Before starting, be sure that you will be able to get a cable where you will cut in the box.

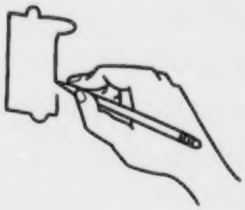
☐ 1. Gather equipment and materials, and put on safety glasses.

☐ 2. Mark box height on wall.

☐ 3. Pencil around box.

Note: Tap along the wall, listening for hollow spaces, or use a stud finder to make sure that a stud will not be in the cut-out for the box.

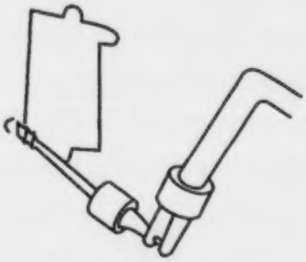
Figure 1



☐ 4. Place drop cloth below work area.

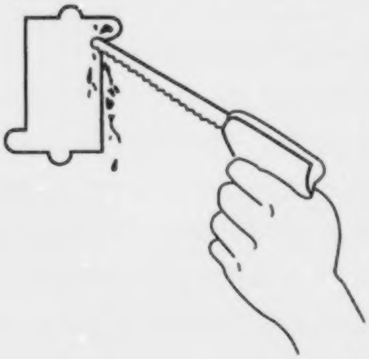
☐ 5. Drill holes in two of the corners.

Figure 2



☐ 6. Saw along drawn lines.

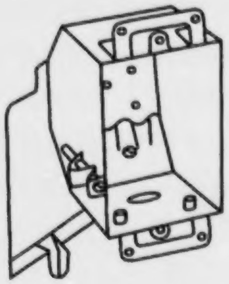
Figure 3



☐ 7. Fit box into opening.

Note: You may need to do some trimming. The plasterboard will chalk white places on the box in areas where trimming is needed.

Figure 4

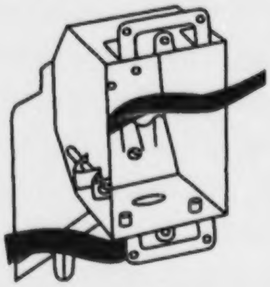


☐ 8. Remove box.

☐ 9. Insert conductors

☐ 10. Replace box in opening.

Figure 5



☐ 11. Secure box.

Note: Tighten screw until box is secure.

☐ 12. Have instructor check your work.

☐ 13. Pick up drop cloth.

☐ 14. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 13

Job Sheet 2—Secure a Box with Dry-Wall Supports (Box Tins)

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

Note: This job sheet deals only with the securing of boxes after the cable has been run and the opening cut.

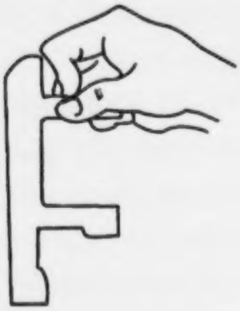
- Dry-wall box with ears
- Dry-wall box supports (box tins)
- Opening in dry wall
- Lineman's pliers

Procedure

☐ 1. Place box in opening.

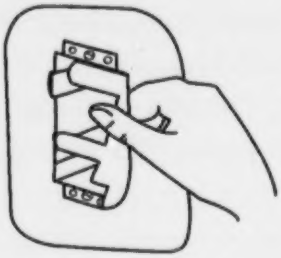
☐ 2. Grip box supports (box tins) in one hand.

Figure 1



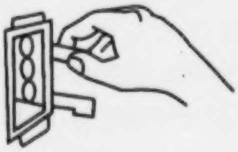
☐ 3. Insert bottom of support beside box.

Figure 2



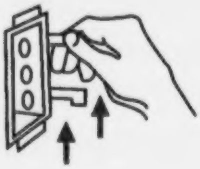
☐ 4. Push in top of support.

Figure 3



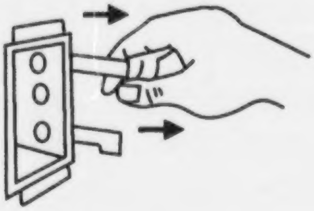
☐ 5. Raise support about 1/2 inch.

Figure 4



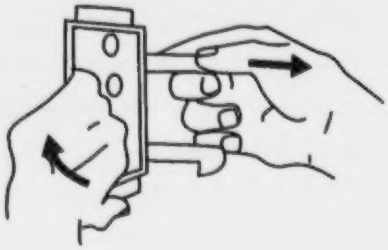
☐ 6. Apply outward pressure on support.

Figure 5



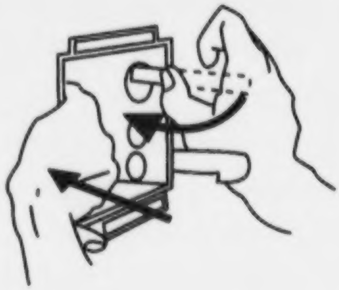
☐ 7. Put inward pressure on box with other hand.

Figure 6



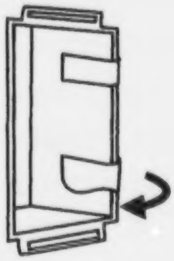
☐ 8. Bend tang over to secure box.

Figure 7



☐ 9. Bend other tang.

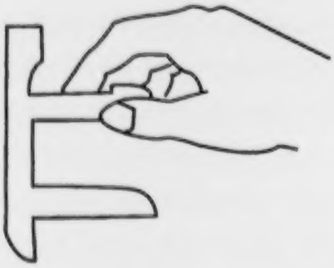
Figure 8



☐ 10. Grasp other support.

Note: This support may be inserted with the long spine in the opposite direction of the first.

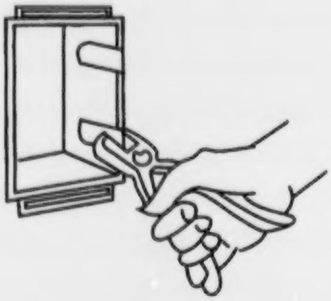
Figure 9



☐ 11. Secure in wall, using Steps 3 through 9.

☐ 12. Pinch tangs with lineman's pliers.

Figure 10



☐ 13. Have instructor evaluate work.

☐ 14. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 14

Job Sheet 3—Install a Plastic Box with Dry-Wall Grips in a Plasterboard Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Plasterboard wall
- Plastic box with dry-wall grips
- Pouch tools
- Keyhole saw
- Pencil
- Safety glasses
- Drop cloth
- Screwdriver
- Drill and bit

Procedure

☐ 1. Gather equipment and materials, and put on safety glasses.

☐ 2. Mark box height on wall.

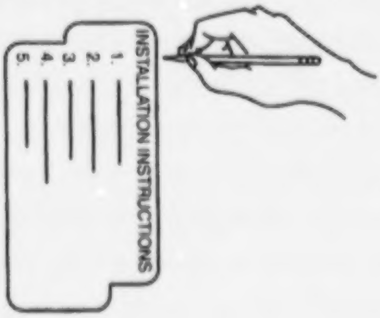
Note: Tap along the wall, listening for hollow spaces, or use a stud finder to make sure that a stud will not be in the cut-out for the box.

☐ 3. Place drop cloth below work area.

☐ 4. Pencil around box.

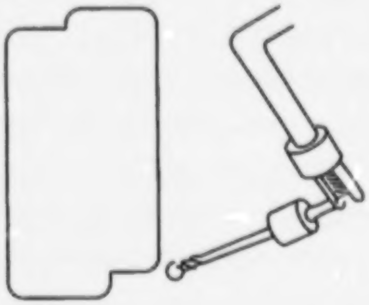
Note: Many manufacturers provide a template. If provided, the template should be used.

Figure 1


INSTALLATION INSTRUCTIONS
1.
2.
3.
4.
5.

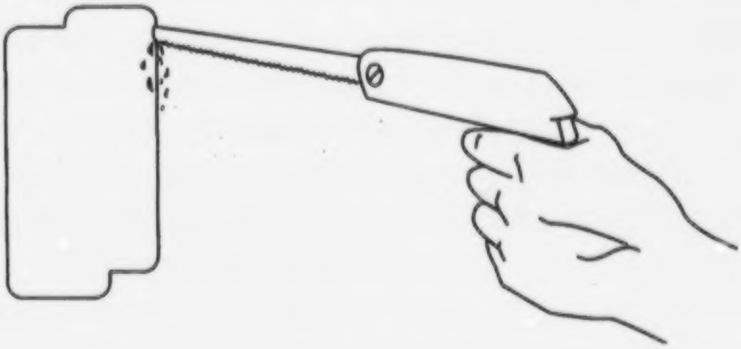
☐ 5. Drill holes in two of the corners.

Figure 2



☐ 6. Saw along drawn lines.

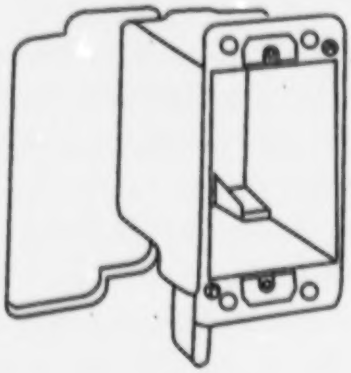
Figure 3



☐ 7. Fit box into opening

Note: You may need to do some trimming to get the box to fit properly.

Figure 4

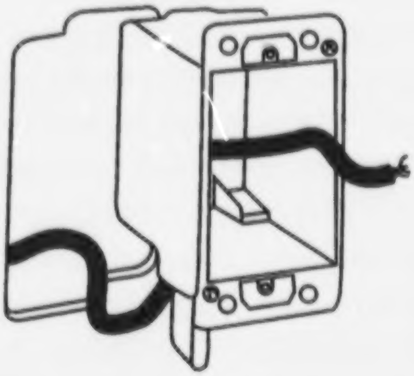


☐ 8. Remove box.

☐ 9. Insert conductors.

☐ 10. Replace box in opening.

Figure 5



☐ 11. Secure box.

Note: Tighten screws until box is secure.

☐ 12. Have instructor check your work.

☐ 13. Pick up drop cloth.

☐ 14. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 15

Job Sheet 4—Install a Box in a Paneled Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Paneled wall
- Pouch tools
- 1/2-inch drill bit
- Brace or drill motor and cord
- Keyhole saw
- Pencil
- Drop cloth
- Switch box with ears
- Masking tape
- Safety glasses
- Portable GFCI
- Four #6 x 3/4-inch metal-tapping or woodscrews
  Note: If plasterboard is behind the paneling, you can use one of the forms of dry-wall grips.

Procedure

Note: Before starting be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and materials and put on safety glasses.

☐ 2. Mark box height on wall.

☐ 3. Pencil around box.

Note: Notice nail locations, use a stud finder, or tap for hollow sounds to make sure that you are in a hollow space.

☐ 4. Put masking tape over lines and re-mark if not visible.

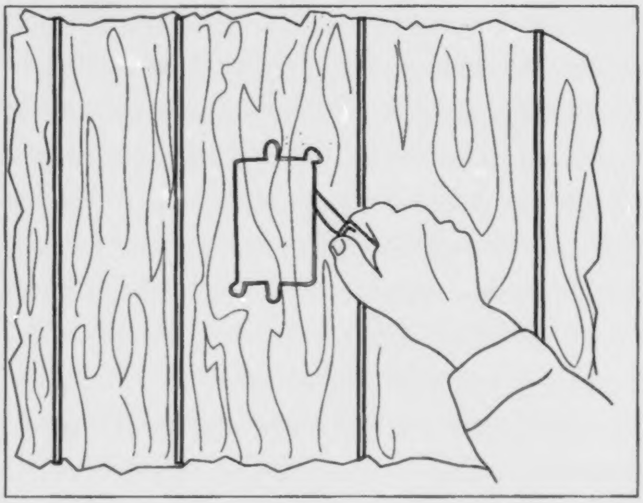
Note: This will prevent wood from splintering while drilling and sawing.

☐ 5. Place drop cloth below work area.

☐ 6. Cut along penciled lines with knife. (Figure 1)

Note: If you do not cut through the top layer of the paneling, it will splinter when you start sawing.

Figure 1



☐ 7. Drill holes in two corners of penciled in box.

Note: Be sure and plug cord in GFCI if a drill motor is used.

☐ 8. Saw out opening.

Note: Saw inside of your knife cut to avoid splintering the panel.

☐ 9. Fit box into opening.

Note: If you have to trim the opening, use your knife instead of the saw to avoid splintering.

☐ 10. Remove box.

☐ 11. Install cable.

☐ 12. Reinstall box in opening.

☐ 13. Secure box.

☐ 14. Remove masking tape.

☐ 15. Have instructor check your work.

☐ 16. Pick up drop cloth.

☐ 17. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

1209

Objective 16

Job Sheet 5—Install a Box in a Concrete Block Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Concrete block wall
- Concrete chisel
- Switch box with ears
- Pencil
- Mortar, commercial pre-mix or sand and cement mixture you blend yourself
- Wood scraps
- Safety glasses

Procedure

Note: Before starting be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and materials and put on safety glasses.

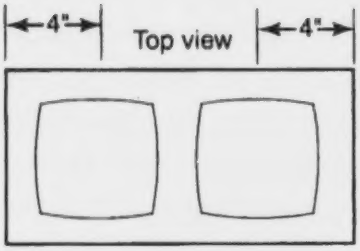
☐ 2. Mark approximate box height.

Note: Make your mark in a mortar joint at the top or bottom edge of a block.

☐ 3. Pencil around box.

Note: Make sure that your box will be centered in a hollow space in the concrete block. There should be a hollow space on an 8" x 8" x 16" block 4 inches from either end.

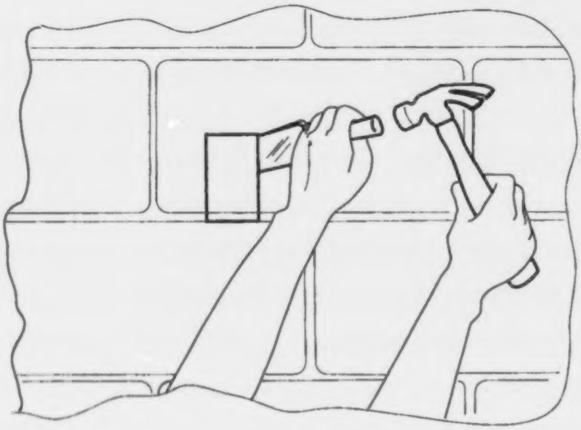
Figure 1



☐ 4. Tap chisel along pencil lines with hammer. (Figure 2)

Note: This should be done until a groove approximately 1/16-inch deep replaces your penciled outline.

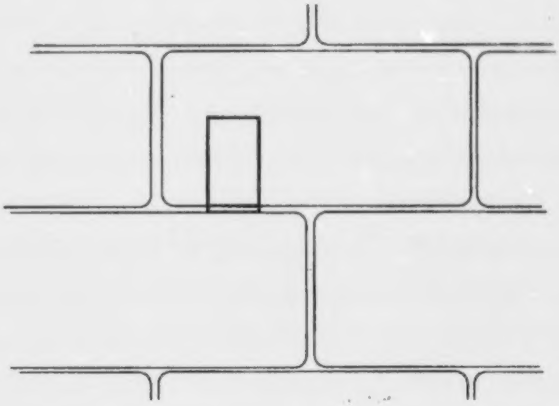
Figure 2



☐ 5. Knock mortar out along box outline. (Figure 2)

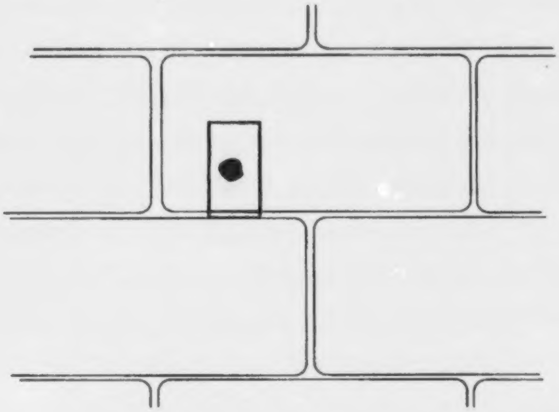
Note: If mortar is difficult to remove, you can drill it out. Be sure to use portable GFCI.

Figure 3



☐ 6. Tap center of box outline with hammer to form a hole. (Figure 4)

Figure 4



☐ 7. Gently tap from center hole toward grooved box outline.

Note: The block should crack off at the groove. Do not hurry. Slowly work around the groove until the opening is formed.

☐ 8. Fit box into opening.

Note: The hole may have to be dressed with the chisel until the box fits.

☐ 9. Remove box.

☐ 10. Install cable in box.

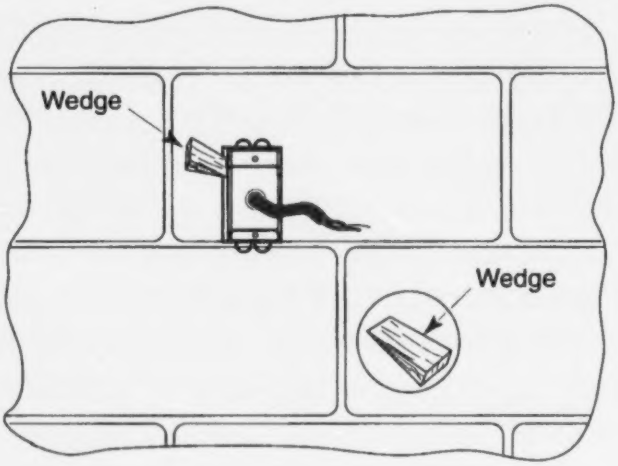
Note: You may have to enter the back of the box; in this event you will need a 3/8-inch cable clamp.

☐ 11. Reinstall box in opening.

☐ 12. Secure box with narrow wood wedges. (Figure 4)

Note: The wedges can be made by chipping at the end of a 2-by-4 with your hammer claws. Put one wedge at the top and one at the bottom in opposite corners.

Figure 5



☐ 13. Flush off wood securing wedges.

Note: Even if the box seems secure, you must use mortar or construction adhesive to finish the process.

☐ 14. Mix a small amount of mortar.

☐ 15. Force mortar between box and opening in block.

☐ 16. Smooth out excess mortar.

☐ 17. Have instructor check your work.

☐ 18. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 17

Job Sheet 6—Install a Box in a Brick Wall

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Brick wall
- Pouch tools
- Switch box with ears
- 2 plastic anchors with appropriate bit and screws
- Concrete chisel
- Pencil
- Mortar
- 3/4-inch cable clamp
- Portable GFCI
- Safety glasses
- Drill motor and cord
- 1/4-inch masonry bit
  Note: The bit could be larger; however, a large bit will usually take more time to make the necessary penetrations.

Procedure

Note: Before starting be sure that you will be able to get a cable to where you will cut in the box.

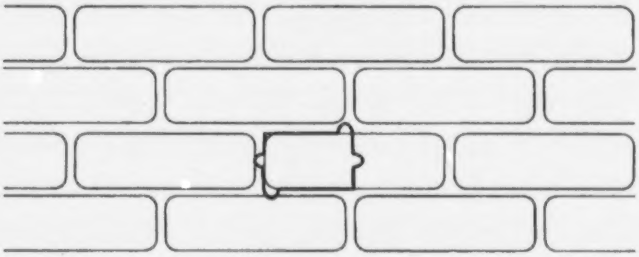
☐ 1. Gather equipment and materials and put on safety glasses.

☐ 2. Mark box height on wall.

☐ 3. Pencil around box. (Figure 1)

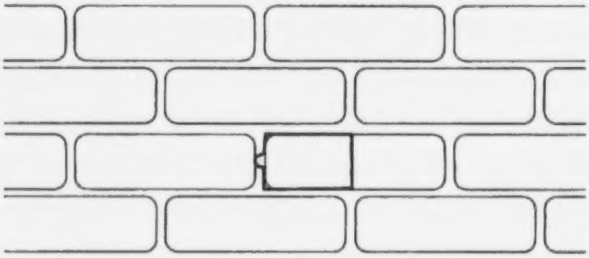
Note: Place the box horizontally so that only one cut is needed in a brick. However, if existing outlets are installed vertically, then this box should also be installed vertically.

Figure 1



☐ 4. Chisel the mortar from around your penciled-in box. (Figure 2)

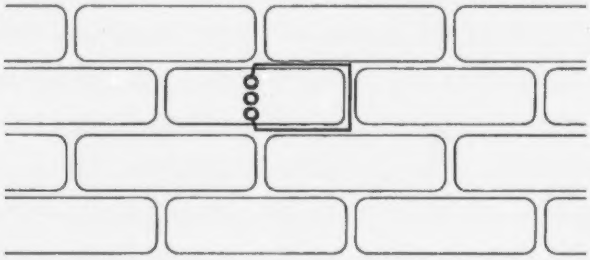
Figure 2



☐ 5. Drill three or four holes along box outline in brick. (Figure 3)

Note: Be sure to use GFCI with your power tools.

Figure 3



☐ 6. Chisel a groove between the drill holes.

Note: The brick may break while you are grooving it.

☐ 7. Tap on the free end of the brick until it breaks.

Note: Do not push the brick bat back into the wall. Remove it from the wall when it breaks.

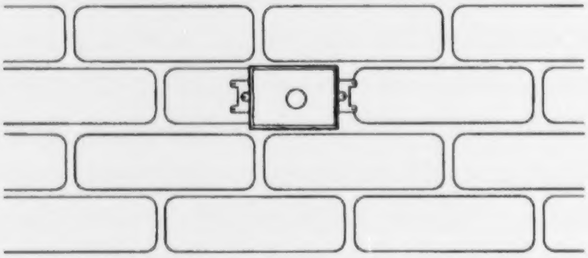
☐ 8. Fit box in opening.

Note: You may have to dress the hole with the concrete chisel.

☐ 9. Mark holes for anchors in plaster ears. (Figure 4)

Note: One in each ear is sufficient

Figure 4



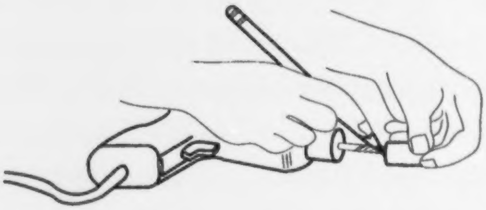
☐ 10. Remove box.

☐ 11. Install anchors.

☐ a. Measure anchor on drill bit. (Figure 5)

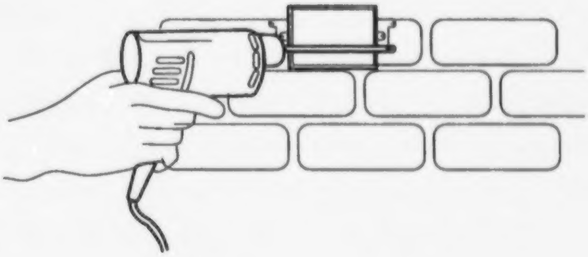
Note: This technique tells you when to stop so that your anchor will bottom out.

Figure 5



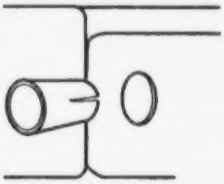
☐ b. Drill hole to marked depth. (Figure 6)

Figure 6



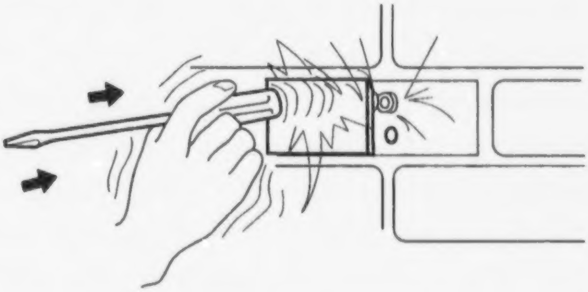
☐ c. Insert small end of anchor in hole. (Figure 7)

Figure 7



☐ d. Tap with screwdriver butt to seat. (Figure 8)

Figure 8



☐ 12. Replace cable in box.

☐ 13. Secure cable clamp.

☐ 14. Insert box in opening.

☐ 15. Install screws in anchor.

☐ 16. Secure box.

☐ 17. Mix mortar.

☐ 18. Fill joints around box.

☐ 19. Smooth joints with finger.

☐ 20. Have instructor check your work.

☐ 21. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 18

Job Sheet 7—Install a Box in a Ceiling with an Accessible Attic

Name ________________ Attempt Number ______

Date ________________ Overall Rating ______

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Keyhole saw
- Octagon box
- Bar hanger
- Pencil
- Drop cloth
- Step ladder
- Safety glasses
- 1/2-inch drill bit
- Brace or drill motor and cord
- 2 single or plasterboard nails
- Trouble light and bulb
- Portable GFCI

Procedure

Note: Before starting be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Gather equipment and material, and put on safety glasses.

☐ 2. Set up ladder.

☐ 3. Place drop cloth under work area.

☐ 4. Mark box location on ceiling.

☐ 5. Pencil around box.

Note: Be sure that there is not a ceiling joist above where you plan on cutting in the box.

☐ 6. Drill a hole in corner of box outline.

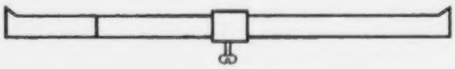
☐ 7. Saw out box opening

Note: If the ceiling is lath, chip the plaster off the inside of your outline before you saw the lath.

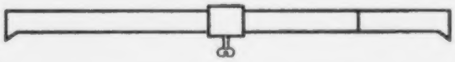
☐ 8. Attach bar to box.

Note: Reverse the bar so that the nail slots are upward for easy nailing. Installation must comply with *NEC* Article 314.27(D).

Figure 1



Reversed bar



Standard

☐ 9. Move ladder to attic access hole.

☐ 10. Plug in drop light.

☐ 11. Go into attic with pouch tools, nails, box and trouble light.

☐ 12. Walk to the box opening, taking care to walk only on ceiling joists.

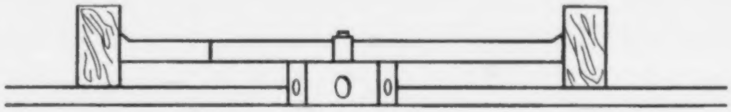
Caution: Do not step between joists, or you may step through the ceiling below.

☐ 13. Position box in hole.

☐ 14. Nail bar hanger between joists.

Note: Be sure that the box is flush with ceiling.

Figure 2



☐ 15. Insert cable in box.

☐ 16. Gather tools and light.

☐ 17. Descend from attic.

☐ 18. Reposition ladder.

☐ 19. Tighten cable clamp and box support screw.

☐ 20. Have instructor check your work.

☐ 21. Pick up drop cloth.

☐ 22. Clean work are, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 19

Job Sheet 8—Install Cable Between an Existing Box and a Newly Installed Box Horizontally Along a Wall in a Channel Behind Baseboard

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Keyhole saw
- 12-2G cable
- Suitable box with some type of dry-wall fasteners
- Drop cloth
- Whisk broom
- Touch up materials, including paint and brush if needed
- Safety glasses
- Chisel
- Flat bar

Procedure

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

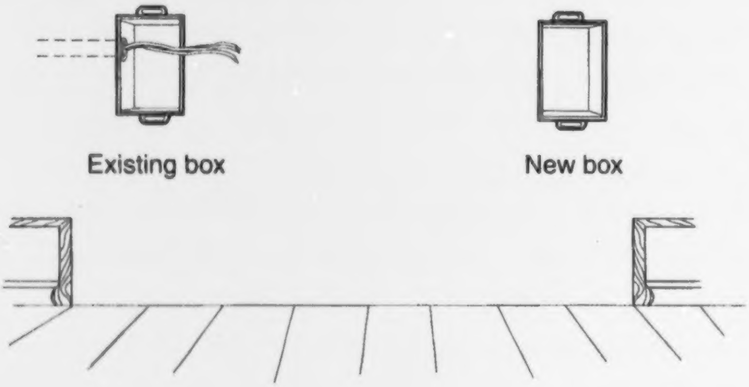
☐ 3. Cut in new box.

Note: Be sure to consider wall covering materials before making your opening.

☐ 4. Remove baseboard between boxes.

Note: The illustrations show the boxes on the same wall. The baseboard will have to be removed from the two walls if you install the new box on another wall.

Figure 1



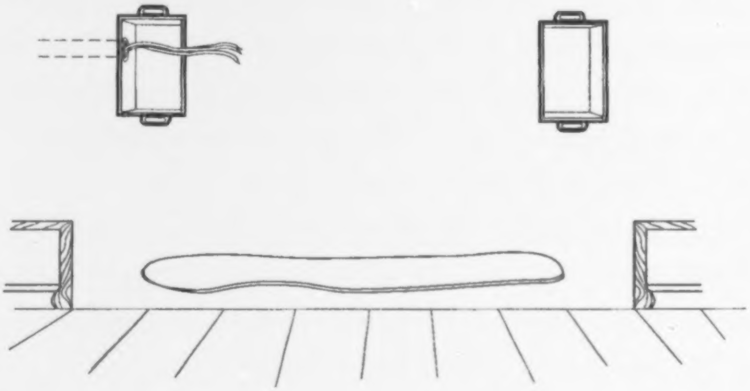
- ☐ a. Pry out baseboard with flat bar, starting at one end and working evenly along baseboard.
- ☐ b. Cut nails flush to baseboard.
- ☐ c. Lay baseboard aside until needed.

☐ 5. Place drop cloth along floor line.

☐ 6. Form channel with hammer and chisel.

Note: Be sure that your channel will be covered by the baseboard. Most older houses have a sufficiently tall baseboard.

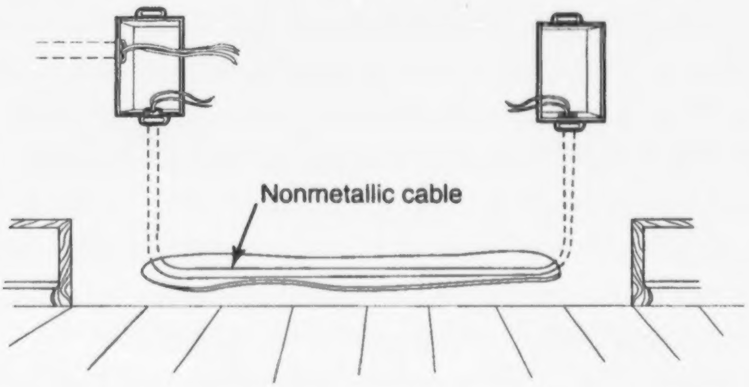
Figure 2



☐ 7. Install cable.

Note: You may have to bore a hole through a piece of lath or through the top edge of a bottom plate.

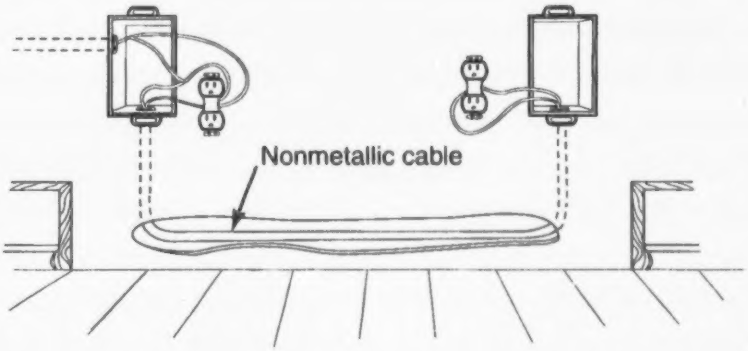
Figure 3


Nonmetallic cable

☐ 8. Install devices.

Note: Refer to *NEC* Article 300-13 for requirements of conductor continuity.

Figure 4

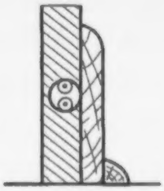

Nonmetallic cable

☐ 9. Replace baseboard.

  ☐ a. Check cable fit.

  Note: The baseboard should fit back flat against the wall.

  Figure 5



  ☐ a. Renail baseboard.

  Caution: Take care not to puncture the cable with the nails.

☐ 10. Touch-up baseboard.

Note: The homeowner may have some of the original paint.

☐ 11. Have instructor check your work.

☐ 12. Pick up drop cloth.

☐ 13. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 20

Job Sheet 9—Install Cable Between an Existing Box and a Newly Installed Box, Using an Underfloor Crawl Space

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Drop light and cord
- Drill motor
- Ship auger bit
- Suitable box with dry-wall fasteners
- 12-2G cable
- Staples
- Drop cloth
- Fish wire
- String
- Tape
- Portable GFCI
- Volt ohmmeter
- Safety glasses

Procedure

Note: Before starting be sure that you will be able to get a cable to where you will cut in the box.

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Cut in new box.

☐ 4. Remove existing device.

☐ 5. Locate crawl space access hole.

☐ 6. Connect GFCI to outlet and cord to GFCI.

☐ 7. Locate place to drill.

Note: A nail can be driven down through the floor, or measurements can be taken from above and transferred to below.

☐ 8. Drill holes (Figures 1 and 2)

Figure 1

Outside wall

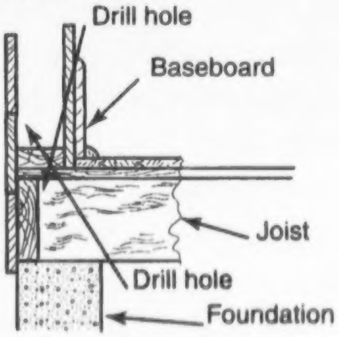
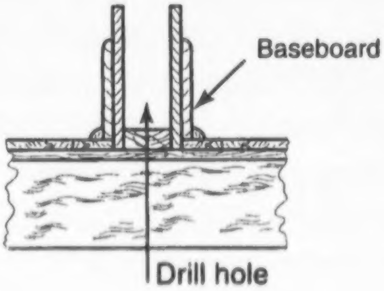

Drill hole
Baseboard
Joist
Drill hole
Foundation

Figure 2

Inside wall


Baseboard
Drill hole

☐ 9. Make opening at existing box for cable.

  ☐ a. Remove a knockout from box.

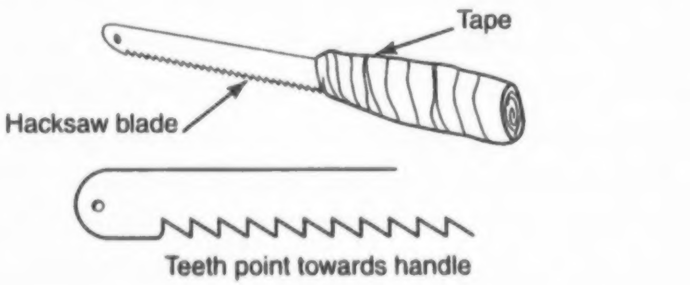
  Note: If a knockout cannot be removed, remove the box.

  ☐ b. Remove box if necessary.

    ☐ (1) Insert saw between box and stud.

    Note: A saw can be constructed with an old or broken hacksaw blade. See Figure 3

Figure 3


Tape
Hacksaw blade
Teeth point towards handle

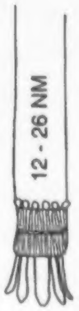
☐ (2) Cut nails.

☐ (3) Move box out of way.

☐ 10. Fish wire through drilled hole.

☐ a. Tape string in loops to cable. (Figure 4)

Figure 4

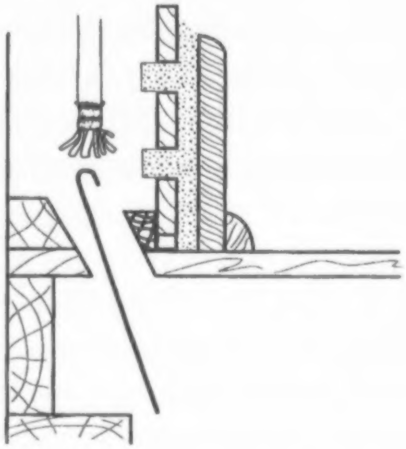


☐ b. Push cable in opening.

Note: Insulation in walls may make it more difficult to fish the wires.

☐ c. Push fish wire with loop up from bottom and wiggle to hook loops. (Figure 5)

Figure 5



☐ d. Pull cable through hole while being fed from above.

Note: This effort needs to be coordinated among the people working. Signals such as two quick jerks for more cable to be fed should be established.

☐ e. Pull cable over the other hole.

☐ f. Push through hole and fish from above.

☐ 11. Staple cable as code requires.

☐ 12. Install new box.

Note: Install original existing box if it was removed.

☐ 13. Install devices.

☐ 14. Activate circuit and test it.

☐ 15. Have instructor check your work.

☐ 16. Reseal crawl space access hole.

☐ 17. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ____

____

____

Objective 21

Job Sheet 10—Install Cable Between an Existing Box and a Newly Installed Box Using an Attic Space

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Pouch tools
- Drop light and cord
- Drill motor
- Ship auger bit
- Suitable box with dry-wall fasteners
- 12-2G cable
- Staples
- Drop cloth
- Drop chain
- Steel fish tape
- Volt ohmmeter
- Ladder (tall enough to allow easy entry into attic)
- Tape
- Safety glasses
- Dust mask
- Portable GFCI

Procedure

Note: Be sure to turn off and check circuit before starting.

☐ 1. Put on safety glasses.

☐ 2. Gather equipment and materials.

☐ 3. Put down drop cloth.

☐ 4. Remove existing device.

☐ 5. Plug in GFCI and drop light.

☐ 6. Set up ladder at access hole.

☐ 7. Put the following materials up in the attic.

  ☐ a. Pouch tools

  ☐ b. Drop chain

  ☐ c. Drop light

  ☐ d. Drill motor and bit

  ☐ e. Distance measured for drilling written on paper

☐ 8. Put on dust mask.

☐ 9. Enter attic carefully.

Note: When traveling across the attic be sure and walk on ceiling joists. You may have to brush insulation aside as you walk to locate them.

☐ 10. Locate spot to drill.

☐ 11. Drill hole.

Note: On inside walls, drilling should be no problem. On outside walls, the pitch of the roof may affect how you get through or around the top plate.

☐ 12. Drop one ned of chain in hole.

Note: You can stick a screwdriver through one end of the chain to be sure that it does not slip from your hand and fall through the hole. Insulated exterior walls may require the use of a solid wire or fish tape.

☐ 13. Shake chain until located below through opening.

☐ 14. Cut in new box.

Note: Measurements should be take carefully so that the holes bored from the attic are in the right stud space.

☐ 15. Pull end of chain through hole.

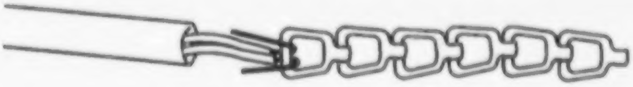
☐ 16. Fasten chain to cable.

  ☐ a. Strip about 6 inches of outer cable sheath.

  ☐ b. Strip about 2 inches of insulation from conductors.

  ☐ c. Insert conductors in chain loops and bend over. (Figure 1)

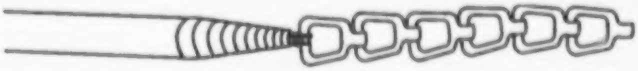
Figure 1



  ☐ d. Tape the connecting joint back over the cable. (Figure 2)

Note: A smooth joint allows the cable to pass through the drilled hole without hanging up.

Figure 2



☐ 17. Pull cable up into attic.

Note: A couple of tugs on the chain can signal the technician in the attic to start pulling up. Cable should be pulled in 2- or 3-foot lifts to allow feed person to straighten cable as it is fed.

☐ 18. Pull enough cable to go over to next hole and down to existing box.

Note: Pull plenty, because you can refeed excess back down to new box before it is cut.

☐ 19. Drill hole above existing outlet.

Note: Sometimes a hole already exists where another cable goes down. Use this space if it is large enough.

☐ 20. Drop chain into hole.

☐ 21. Fish chain out of existing box.

Note: If a knockout will not allow you to fish chain, cut nails and remove box.

☐ 22. Pull out enough cable for installation.

☐ 23. Pull excess back through new hole.

☐ 24. Staple cable in attic.

☐ 25. Remove equipment and materials from attic.

Note: The technician below should be waiting to receive materials as they are handed down.

☐ 26. Replace attic access cover.

☐ 27. Install devices.

☐ 28. Activate circuit.

☐ 29. Test devices.

☐ 31. Have your instructor check your work.

☐ 32. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ____________________

____

____

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

NOTICE

Reproduction Basis

☒ This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

☐ This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").